

(11)Publication number : 2003-172939
 (43)Date of publication of application : 20.06.2003

(51)Int.Cl.

G02F 1/1343

(21)Application number : 2001-373438

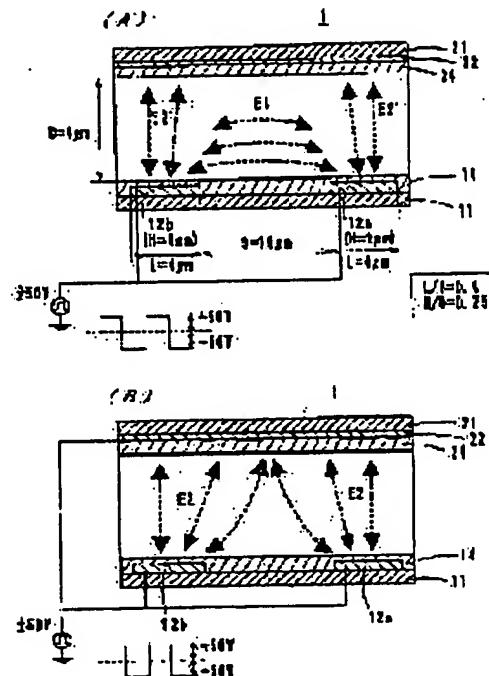
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(22)Date of filing : 06.12.2001

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NOZAKI CHIYOJI**(54) LIQUID CRYSTAL DISPLAY DEVICE****(57)Abstract:**

PROBLEM TO BE SOLVED: To obtain a liquid crystal display device in which contrast of an image is enhanced.

SOLUTION: In the device, chiral nematic liquid crystals are held between a substrate 11 which is provided with comb-shaped electrodes 12a and 12b and a substrate 21 which is provided with a flat surface electrode 22 and display is conducted by utilizing selective reflection of the liquid crystals. When the electrode width of the electrodes 12a and 12b is defined as L, and the gap between the electrodes is defined as S, it is satisfied to be $0.1 \leq L/S \leq 0.6$. It is desired to set $1 \mu\text{m} \leq L \leq 5 \mu\text{m}$ and $6 \mu\text{m} \leq S \leq 20 \mu\text{m}$. Moreover, when the thickness of the electrodes 12a and 12b is defined as H and the gap is defined as D, it is satisfied to be $0.1 < H/D < 1$. When such conditions are set, longitudinal electric field E2' on the electrodes 12a and 12b is suppressed as much as possible when lateral electric field E1 is generated.

**LEGAL STATUS**

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] The liquid crystal display characterized by being $0.1 \leq \text{last shipment} \leq 0.6$ when it had the substrate of a couple, the liquid crystal in which the cholesteric phase pinched between these substrates is shown, and the electrode which impresses almost parallel electric field to a substrate at least, and the ctenidium-like electrode was formed in one [at least] substrate, and electrode width of face of this ctenidium-like electrode is set to L and it sets inter-electrode spare time to S.

[Claim 2] Said ctenidium-like electrode is a liquid crystal display according to claim 1 characterized by being 1 micrometer $\leq L \leq 5$ micrometer and/or 6 micrometer $\leq S \leq 20$ micrometer.

[Claim 3] The liquid crystal display characterized by being $0.1 < H/D < 1$ when it has the substrate of a couple, the liquid crystal in which the cholesteric phase pinched between these substrates is shown, and the electrode which impresses almost parallel electric field to a substrate at least, the ctenidium-like electrode is formed in one [at least] substrate and the gap between H and said substrate is set to D for the electrode thickness of this ctenidium-like electrode.

[Claim 4] The substrate of a couple, and the liquid crystal in which the cholesteric phase pinched between these substrates is shown, It has the electrode which impresses almost parallel electric field to a substrate at least. The liquid crystal display characterized by being $0.1 \leq \text{last shipment} \leq 0.6$ and $0.1 < H/D < 1$ when the ctenidium-like electrode was formed in one [at least] substrate, and L and inter-electrode spare time are set to S and it sets [the electrode width of face of this ctenidium-like electrode] the gap between H and said substrate to D for electrode thickness.

[Claim 5] Claim 1 characterized by said liquid crystal having memory nature, claim 2, a liquid crystal display according to claim 3 or 4.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the liquid crystal display which pinches a liquid crystal display and the liquid crystal in which a cholesteric phase is shown, and displays between the substrates of a couple especially using the selective reflection of this liquid crystal.

[0002]

[Description of the Prior Art] Conventionally, the chiral nematic liquid crystal in which cholesteric liquid crystal and a cholesteric-liquid-crystal phase are shown is pinched between the substrates of a couple, parallel horizontal electric field are impressed to a substrate side, and the liquid crystal display which displays by changing the condition of liquid crystal is proposed (for example, refer to JP,7-120792,A and JP,2001-83485,A). There is also an example which superimposes vertical electric field at the time of impression of horizontal electric field (refer to JP,2001-100256,A).

[0003] By the way, in the conventional liquid crystal display using the liquid crystal in which the cholesteric phase which the condition of liquid crystal is changed and displays an image by impression of horizontal electric field is shown, in order to generate horizontal electric field, the electrode arranged at one [at least] substrate was made into the shape of a ctenidium. Although horizontal electric field occurred when it made this ctenidium-like inter-electrode produce the potential difference, it changed into the condition that it is not made to switch so that the liquid crystal which exists on a ctenidium-like electrode at this time may be meant, consequently the liquid crystal on an electrode checks a display, and had the trouble that the contrast of an image fell.

[0004] Then, when the object of this invention generates parallel horizontal electric field to a substrate, it is to offer the liquid crystal display which can suppress generating of the uncontrollable liquid crystal field which exists on an electrode as much as possible, and can raise the contrast of an image.

[0005]

[The configuration, an operation, and effectiveness] of invention In order to attain the above object, the liquid crystal display concerning the 1st invention The substrate of a couple, and the liquid crystal in which the cholesteric phase pinched between these substrates is shown, When have the electrode which impresses almost parallel electric field to a substrate at least, the ctenidium-like electrode is formed in one [at least] substrate, electrode width of face of a ctenidium-like electrode is set to L and inter-electrode spare time is set to S, it is characterized by being $0.1 \leq L \leq 0.6$. Furthermore, as for said ctenidium-like electrode, it is desirable that they are 1 micrometer $\leq L \leq 5$ micrometer and/or 6 micrometer $\leq S \leq 20$ micrometer.

[0006] The liquid crystal which the liquid crystal display concerning the 2nd invention shows the cholesteric phase by which it was pinched between the substrate of a couple, and this substrate, When have the electrode which impresses almost parallel electric field to a substrate at least, the ctenidium-like electrode is formed in one [at least] substrate, electrode thickness of a ctenidium-like electrode is set to H and the gap between said substrates is set to D, it is characterized by being $0.1 \leq H/D \leq 1$.

[0007] Generally, if the liquid crystal in which a cholesteric phase is shown changes in the direction in which the direction of electric field and the helical shaft cross at right angles if a dielectric constant anisotropy is in forward liquid crystal and a dielectric constant anisotropy is in negative liquid crystal when a predetermined electrical potential difference is impressed, the helical shaft changes in the direction parallel to the direction of electric field. In this case, to a substrate side, by the perpendicular direction or generating electric field selectively in parallel, helical shafts are a perpendicular direction and changing horizontally and maintaining a cholesteric phase mostly to a substrate, set each pixel as a planar condition or a focal conic condition, and liquid crystal displays an image.

[0008] The electrode width of face L of the ctenidium-like electrode with which this invention person impresses almost parallel horizontal electric field to a substrate The gap D between the inter-electrode spare time S, electrode thickness H, and a substrate is made into a parameter. The liquid crystal field out of control generated right above [of an electrode] when generating

horizontal electric field was decreased, as a result of experimenting by changing these parameters to various values, it could prevent that it will be in the condition that the liquid crystal on an electrode checks a display as much as possible, and the conditions whose contrast improves were solved, and it resulted in this invention.

[0009] That is, in the electrode width of face L and relation with the inter-electrode spare time S, desirable contrast could be acquired under the conditions of $0.1 \leq \text{last shipment} \leq 0.6$, and the electrode width of face L was able to acquire desirable contrast especially by the time of 1 micrometer $\leq L \leq 5$ micrometer and the inter-electrode spare time S being 6 micrometer $\leq S \leq 20$ micrometers. It is more preferably referred to as $0.25 \leq \text{last shipment} \leq 0.5$.

[0010] Moreover, in the relation between electrode thickness H and the gap D between substrates, desirable contrast was able to be acquired under the conditions of $0.1 \leq H/D \leq 1$. It is more preferably referred to as $0.2 \leq H/D \leq 0.7$.

[0011] A liquid crystal display may be the configuration which has said the 1st invention and invention of the 2nd. If it has both, it is effective by improvement in contrast. Moreover, if liquid crystal uses what has memory nature, power-saving can be attained and it will become a thing suitable for a personal digital assistant.

[0012]

[Embodiment of the Invention] Hereafter, the operation gestalt of the liquid crystal display concerning this invention is explained with reference to an accompanying drawing.

[0013] (An actuation principle, drawing 1 , 2 reference) The liquid crystal display concerning this invention displays based on various actuation principles, and explains an in-every-direction electric-field change method and an IPS (In-Plane-Switching) method as the typical actuation principle.

[0014] An in-every-direction electric-field change method is equipped with a means to impress the means and horizontal electric field which impress vertical electric field, is not with solution Lycium chinense thoroughly about torsion of the liquid crystal (it represents with a chiral nematic liquid crystal hereafter) in which a cholesteric phase is shown by both switch, and are almost vertical and a thing which displays by making it change to parallel mostly to a substrate preferably at a predetermined include angle to a substrate about the helical shaft.

[0015] A chiral nematic liquid crystal is obtained by adding the chiral material of the specified quantity to a nematic liquid crystal. As shown in drawing 1 (A), generally as for this chiral nematic liquid crystal, the rod-like liquid crystal molecule shows nothing and a cholesteric phase for the distorted array. When light carried out incidence to this liquid crystal and light carries out incidence from a parallel direction to a helical shaft, selective reflection of the light of the wavelength shown by $\lambda = np$ is carried out (planar condition). Here, λ is the distance (it is hereafter described as a spiral pitch) in which wavelength and n can twist the average refractive index of a liquid crystal molecule, and p has twisted 360 degrees of liquid crystal molecules. On the other hand, light is scattered about when light carries out incidence from a vertical direction to a helical shaft (focal conic condition). When the selective reflection wavelength in a planar condition is set as the light field, dispersion in the focal conic condition becomes weak, and penetrates incident light substantially. A display is performed using this selective reflection and dispersion (transparency). In addition, the cholesteric phase of liquid crystal is shown also like drawing 1 (B).

[0016] By the way, although the liquid crystal molecule is cylindrical, it has the anisotropy from which a refractive index and a dielectric constant differ in the longitudinal direction (major axis) and a direction (minor axis) vertical to it. A dielectric constant anisotropy calls liquid crystal with larger refractive index and dielectric constant of the direction of a major axis of a liquid crystal molecule than them of the direction of a minor axis forward liquid crystal. If a dielectric constant anisotropy impresses an electrical potential difference high enough to forward liquid crystal, torsion will be cleared, and it moves so that the major axis (shaft with a large dielectric constant) of a liquid crystal molecule may be suitable in the direction parallel to the direction of electric field. A threshold exists in the electrical potential difference which this torsion solves, and this threshold voltage is set to V_h .

[0017] Moreover, if an electrical potential difference lower than said threshold voltage V_h is

impressed to liquid crystal, liquid crystal will move so that there may be nothing with solution Lycium chinense about torsion and a helical shaft may be suitable in the vertical direction to the direction of electric field. A threshold exists also in the electrical potential difference to which this helical shaft is moved, and this threshold voltage is set to Vf.

[0018] The relation of such threshold voltage Vh and Vf is $Vf < Vh$. Moreover, even if it impresses an electrical potential difference lower than threshold voltage Vf to liquid crystal, a liquid crystal molecule does not move, namely, helical shaft orientations do not change.

[0019] On the other hand, a dielectric constant anisotropy calls liquid crystal with the dielectric constant of the direction of a major axis smaller than that of the direction of a minor axis negative liquid crystal more greatly [the refractive index of the direction of a major axis of a liquid crystal molecule] than that of the direction of a minor axis. If a dielectric constant anisotropy impresses an electrical potential difference high enough to negative liquid crystal, there will be nothing with solution Lycium chinense about torsion, and a helical shaft will turn to the direction of electric field at random not related. This phenomenon is called dynamic scattering. A threshold exists in the electrical potential difference to which this phenomenon happens, and threshold voltage is set to Vd.

[0020] Moreover, if an electrical potential difference lower than said threshold voltage Vd is impressed to liquid crystal, liquid crystal will move so that there may be nothing with solution Lycium chinense about torsion and a helical shaft may be suitable in the parallel direction to the direction of electric field. A threshold exists also in the electrical potential difference to which this helical shaft is moved, and this threshold voltage is set to ***.

[0021] The relation of such threshold voltage Vd and *** is *** < Vd. Moreover, even if it impresses an electrical potential difference lower than threshold voltage *** to liquid crystal, a liquid crystal molecule does not move, namely, helical shaft orientations do not change.

[0022] On the other hand, an IPS method is a method which displays by impressing parallel horizontal electric field to a substrate, and has the following gestalten as an example. That is, as shown in drawing 2 (A), the dielectric constant anisotropy which adjusted the spiral pitch p so that wavelength lambda might be set to about 350nm pinches the forward chiral nematic liquid crystal between a substrate 11 and 21. Although a planar condition with a helical shaft vertical to a substrate side is held in the condition of not impressing an electrical potential difference between electrode 12a and 12b, since it is short, wavelength lambda is not viewed but that of selective reflection light is in a non-display condition.

[0023] Here, if the horizontal electric field E1 are generated between electrode 12a and 12b as shown in drawing 2 (B), according to field strength (electrical potential difference), as for liquid crystal, a spiral pitch (amount in which a spiral is undone) will change. For example, if the spiral pitch p is controlled so that wavelength lambda is set to 470nm, selective reflection of the blue light will be carried out, if it controls to 550nm, selective reflection of the green light will be carried out, and if it controls to 660nm, selective reflection of the red light will be carried out. At the time (superimposed on vertical electric field at this time) of no electrical-potential-difference impressing, there are also selective reflection and a gestalt which displays by considering as transparency at the time of electrical-potential-difference impression besides this.

[0024] (An operation gestalt, drawing 3 - 10 reference) Drawing 3 - 10 are the liquid crystal cell used in the examples 1-8 of an experiment explained below, and they show roughly 1/several - 1/about ten of the pixel of one unit. Then, with reference to drawing 3 - 10, the liquid crystal display component 1 which is 1 operation gestalt is explained.

[0025] This liquid crystal display component 1 forms Electrodes 12a and 12b and the orientation control film 14 in the lower substrate 11, forms an electrode 22 and the orientation control film 24 in the upper substrate 21, and consists of a configuration which pinched the substrate 11 and the chiral nematic liquid crystal prepared as chiral material was added to a nematic liquid crystal and a room temperature showed a cholesteric phase to it among 21.

[0026] As liquid crystal, if a room temperature shows a cholesteric phase, various things can be used. a dielectric constant anisotropy -- positive/negative -- you may be which thing.

[0027] Various things, such as plastic films, such as glass, polyether sulfone (PES), polyethylene

terephthalate (PET), and a polycarbonate (PC), can be used for the ingredient of substrates 11 and 21. A lightweight and thin thing is desirable. Transparent electrode ingredients, such as ITO and IZO, can be used for the ingredient of electrodes 12a, 12b, and 22, and it may use non-transparent electrode ingredients, such as aluminum and Cu, for the electrodes 12a and 12b of the bottom substrate 11. Electrodes 12a and 12b may be arranged to two steps through an insulator layer 13 (refer to drawing 12). The orientation control film 14 and 24 is formed so that electrodes 12a, 12b, and 22 may be covered. An insulator layer 13 and the orientation control film 14 and 24 can use a well-known ingredient conventionally.

[0028] in addition, the electrodes 12a and 12b -- each -- it is the electrode of the shape of a ctenidium which extended in the direction which intersects perpendicularly with the space of drawing 3 -11, and arranged by turns to the longitudinal direction of space, and has been arranged at it. an electrode 22 has the width of face for at least 1 pixel -- each -- it may be the electrode which extends in the longitudinal direction of drawing 3 -11, and you may be the whole surface electrode which covers the whole image display side.

[0029] in order [furthermore,] to hold the gap between a substrate 11 and 21 uniformly and uniformly -- the need -- responding -- the particle for spacers to between a substrate 11 and 21 -- the resin structure of the shape of pillar-shaped or a wall is arranged. Moreover, the optical absorption layer which absorbs the light is prepared in the rear face of the lower substrate 11. A light absorption function may be given to substrate 11 the very thing.

[0030] Moreover, it is desirable to prepare a sealant in the perimeter of substrates 11 and 21, and to close liquid crystal between substrates. In addition, although the rubbing processing to the orientation control film 14 is theoretically unnecessary, rubbing processing (for example, ten or less rubbing consistency) that a consistency is low, and partial rubbing processing are performed, and you may make it raise the reflection factor in the planar condition of liquid crystal. Orientation control film 14 the very thing may be omitted.

[0031] When it drives so that the electrical-potential-difference difference more than Vf may be produced lower among electrode prepared in substrate 11 side if it was in chiral nematic liquid crystal which has forward dielectric constant anisotropy in liquid crystal display component 1 which consists of above configuration 12a, and 12b than Vh, as it is shown in drawing 3 (A), the horizontal electric field E1 parallel to a substrate side occur, and it is suitable in the direction where the helical shaft of liquid crystal is almost vertical to a substrate side. That is, liquid crystal will be in a planar condition and the selective reflection of predetermined wavelength will produce it.

[0032] If it drives so that the electrical-potential-difference difference more than Vf may be produced between electrode 12a and/or 12b, and an electrode 22 on the other hand lower than Vh, as shown in drawing 3 (B), the vertical electric field E2 vertical to a substrate side will occur, and the helical shaft of liquid crystal will be suitable in the direction parallel to a substrate side. That is, liquid crystal will be in a focal conic condition, and will penetrate light.

[0033] Moreover, if it drives so that the electrical-potential-difference difference more than **** may be produced lower among electrode 12a and 12b than Vd, in order to move so that the helical shaft may be parallel to the direction of electric field, if it is in the chiral nematic liquid crystal which has a negative dielectric constant anisotropy, it will be in a sense and focal conic condition in the direction where the helical shaft of liquid crystal is parallel to a substrate side. If it drives so that the electrical-potential-difference difference more than **** may be produced between electrode 12a and/or 12b, and an electrode 22 on the other hand lower than Vd, liquid crystal will be in the sense and a planar condition in the direction where a helical shaft is almost vertical to a substrate side.

[0034] If the potential difference is produced and the horizontal electric field E1 are generated between electrode 12a and 12b as shown in drawing 3 (A) – drawing 11 (A), on electrode 12a and 12b, vertical electric-field E2' occurs simultaneously, it will be in the condition that liquid crystal differs from the horizontal electric field E1 selectively by this vertical electric-field E2', a display will be checked, and the contrast of an image will fall. Moreover, even if it is in an IPS method, as shown in drawing 2 (B), it will be in the condition of vertical electric-field E2' occurring and checking a display, and an improvement is required.

[0035] In order to control enough the effect of vertical electric-field E2', it is made to fill the relation between either the following type (1) or a formula (2). That is, it is $0.1 \leq \text{last shipment} \leq 0.6$, when L and inter-electrode spare time are set to S and H and the gap between substrates (it is hereafter described also as a cel gap) are set [the electrode width of face of a ctenidium-like electrode] to D for electrode thickness. (1)

$0.1 \leq H/D \leq 1$ (2)

It carries out.

[0036] Here, it is necessary to impress high tension with the lack of field strength of the horizontal electric field E1 as it is last shipment < 0.1 . Moreover, the reflection factor at the time of a focal conic status selection becomes it high that it is last shipment > 0.6 too much, and contrast falls. It is more desirable to set the range of last shipment to $0.25 \leq \text{last shipment} \leq 0.5$.

[0037] When the electrode width of face L is 1 micrometer or less, since the electrode is thin, an open circuit increases, the rate of mass production falls, and a production cost goes up. Moreover, when larger than 5 micrometers, the reflection factor at the time of a focal conic status selection becomes [the electrode width of face L] high too much, and contrast falls. It is desirable to be referred to as 1 micrometer $\leq L \leq 5$ micrometer from such a viewpoint.

[0038] When the inter-electrode spare time S is less than 6 micrometers, the reflection factor at the time of a focal conic status selection becomes high too much, and contrast falls. Moreover, when the inter-electrode spare time S exceeds 20 micrometers, it is necessary to impress high tension with the lack of field strength of the horizontal electric field E1. It is desirable to be referred to as 6 micrometer $\leq S \leq 20$ micrometer from such a viewpoint.

[0039] On the other hand, when H/D is 0.1 or less, the reflection factor at the time of a focal conic status selection becomes high too much, and contrast falls. When H/D is 1, an electrode reaches an opposite substrate side and there is a possibility of producing a short circuit etc. It is more desirable to set the range of H/D to $0.2 \leq H/D \leq 0.7$.

[0040] Electrode thickness H has desirable 10 micrometers or less from the point of processing techniques, such as membrane formation and etching. Moreover, when an electrode is too thin, since it is, the thing whose liquid crystal fields uncontrollable by horizontal electric field increase in number too much and which is set to at least 0.5 micrometers or more is desirable [it is afraid, and].

[0041] The gap D between substrates has desirable 10 micrometers or less, in order to be anxious about decline in the permeability at the time of a focal conic status selection, or high-tension-ization of driver voltage, if it becomes not much large. Moreover, since there is a possibility that sufficient contrast cannot be taken when the gap D between substrates is too small, it is desirable to be referred to as at least 2 micrometers or more.

[0042] (Refer to the example of an electrode configuration for passive-matrix actuation, the actuation approach, and drawing 12) Here, in said operation gestalt, the example of 1 configuration of electrodes 12a, 12b, and 22 prepared in substrates 11 and 21 is collectively shown and explained to be drawing 12 about the actuation approach.

[0043] Scan electrode 12a prepared in the substrate 11 is formed as a ctenidium-like electrode with the detailed die length corresponding to the magnitude of one side of 1 pixel, and signal-electrode 12b is formed as a detailed ctenidium-like electrode by which the group division was carried out corresponding to the magnitude of the 1-pixel other sides. The reset electrode 22 prepared in the substrate 21 is formed as a whole surface electrode corresponding to an image display field.

[0044] The reset electrode 22 is connected to the scan signal / reset-signal actuation circuit 27 through the contact lines 25 and 26. Scan electrode 12a is also connected to this scan signal / reset-signal actuation circuit 27. Moreover, signal-electrode 12b is connected to the data signal actuation circuit 29.

[0045] If it is aimed at the chiral nematic liquid crystal which has a forward dielectric constant anisotropy when newly writing in a display, or when updating, the electrical-potential-difference difference more than Vf will be first produced between scan electrode 12a and the reset electrode 22 lower than Vh. Now, the liquid crystal of the sense and all pixels is reset by the

focal conic condition in the direction where the helical shaft of liquid crystal is parallel to a substrate side.

[0046] Next, the electrical-potential-difference difference more than V_f is produced between scan electrode 12a and signal-electrode 12b to the pixel which writes in an image lower than V_h . Only the liquid crystal of a pixel with which the sense and an electrical potential difference were impressed now in the direction where the helical shaft of liquid crystal is almost vertical to a substrate side changes to a planar condition. This image write-in actuation is based on the passive-matrix actuation method which gives a pulse signal based on image data to signal-electrode 12b, choosing scan electrode 12a of one line at a time.

[0047] When aimed at the chiral nematic liquid crystal which has a negative dielectric constant anisotropy on the other hand, the electrical-potential-difference difference more than **** is first produced between scan electrode 12a and the reset electrode 22 lower than V_d , and the liquid crystal of all pixels is reset in the planar condition. Then, the electrical-potential-difference difference more than **** will be produced between scan electrode 12a and signal-electrode 12b lower than V_d , and the liquid crystal of an every predetermined pixel of one line will be set to the focal conic condition along with scan electrode 12a.

[0048] In addition, in passive-matrix actuation, the electrical potential difference (cross talk electrical potential difference) supplied from an actuation circuit also to the pixel (liquid crystal) used as the object for actuation is impressed. However, if this cross talk electrical potential difference is stopped lower than threshold voltage V_f and ****, the condition of liquid crystal will not change.

[0049] By the way, in the example of an electrode configuration shown in drawing 12, scan electrode 12a can also be driven by the division reset method changed in two or more [of a pixel / per every line], or the direction aiming at a helical shaft after resetting two or more lines simultaneously besides driving by the package reset method mentioned above. Moreover, it can drive also by the individual actuation method which sets the helical shaft in the direction of the object for every pixel, without making it reset.

[0050] (Many modes of electric-field grant) The electric field given in order to change the helical shaft orientations of liquid crystal can adjust a direction and reinforcement by controlling the potential impressed to an electrode. Although said operation gestalt showed the electrode of 3 pole configurations made to generate the horizontal electric field E1 and the vertical electric field E2, an electrode configuration employable as a liquid crystal display concerning this invention is not limited to three poles. For example, two substrates 11 shown in drawing 3 -10 are made to counter, and it considers as a liquid crystal cell, and is good also as 4 pole configurations by Electrodes 12a and 12b.

[0051] Moreover, if it is in the IPS method shown in drawing 2, Electrodes 12a and 12b are formed only on a substrate 11, and the configuration which does not form an electrode is adopted as a substrate 21. The electrode for superimposing vertical electric field at the time of horizontal electric-field impression may be prepared in the substrate 21.

[0052] this invention persons The electrode width of face L, inter-electrode spare time S of Electrodes 12a and 12b (Explanation of the example of an experiment) Make electrode thickness H and a substrate 11, and the gap D between 21 into a parameter, and these parameters are changed to various values. The reflection factor when impressing an electrical potential difference between electrode 12a and 12b, and generating the horizontal electric field E1 was measured, and the conditions on which electrode 12a and vertical electric-field E2' generated on 12b decrease were solved. The result is explained below.

[0053] all the following examples 1-8 of an experiment, and examples 1 of comparative experiments -- setting -- as a chiral nematic liquid crystal -- the liquid crystallinity compound ZLI-2806 (Merck Co. make) 80 weight section -- chiral material -- the 16 weight sections and liquid crystal constituent A whose peak wavelength of selective reflection 4 weight sections addition is carried out, it has a negative dielectric constant anisotropy, and is about 630nm was prepared for CB-15 and R-1011 (all are the Merck Co. make), respectively.

[0054] Therefore, if the potential difference is produced and the horizontal electric field E1 are generated between electrode 12a and 12b, the liquid crystal constituent A will be in a focal conic

condition. moreover — the case where a planar condition is chosen — Electrodes 12a and 12b — what is necessary is to produce the potential difference between either and an electrode 22 at least, and just to generate the vertical electric field E2 In addition, said liquid crystal constituent has the property (memory nature) which can maintain a planar condition, a focal conic condition, and the condition that both were intermingled, in the state of no electrical-potential-difference impressing.

[0055] Moreover, the liquid crystal panel was manufactured by the following ingredients and the approach as the examples 1–8 of an experiment, and an example 1 of comparative experiments. That is, the ITO film was formed in the substrate 11 which consists of a polycarbonate film, and patterning of the electrodes 12a and 12b was carried out by the photolithography method. the orientation control film 14 — : made from JSR — it formed by flexographic printing using 2022. On the other hand, the ITO film was formed in the substrate 21 which consists of a polycarbonate film, and the electrode 22 was formed by the photolithography method. the orientation control film 24 — : made from JSR — it formed by flexographic printing using 2022.

[0056] Said substrates 11 and 21 were stuck on the condition of having pinched said liquid crystal constituent A and the gap attachment component. In order to prevent that substrate spacing becomes narrow, the spherical spacer was used for the gap attachment component, in order to prevent that substrate spacing spreads, the adhesives of an urethane system were used, and the pillar-shaped resin structure of height [a little] higher than the diameter of a spacer has been arranged in the shape of a grid. Moreover, the periphery section of a substrate was closed by the sealant. In addition, the spacer used the thing of the particle size doubled with the dimension of the cel gap D.

[0057] (Refer to the example 1 of an experiment, and drawing 3) In the example 1 of an experiment, 1 micrometer and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 4 micrometers and the inter-electrode spare time S] to 4 micrometers for 10 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.40 and H/D=0.25. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **50V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0058] The planar condition which the reflection factor in this focal conic condition was stopped to about 4%, and was generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0059] (Refer to the example 2 of an experiment, and drawing 4) In the example 2 of an experiment, 1.5 micrometers and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 3 micrometers and the inter-electrode spare time S] to 4 micrometers for 12 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.25 and H/D=0.375. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **50V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0060] The planar condition which the reflection factor in this focal conic condition was stopped to about 3.5%, and was generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0061] (Refer to the example 3 of an experiment, and drawing 5) In the example 3 of an experiment, 2 micrometers and the cel gap D were set [the electrode width of face L of

Electrodes 12a and 12b / 5 micrometers and the inter-electrode spare time S] to 4 micrometers for 10 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.50 and H/D=0.50. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **45V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0062] The planar condition which the reflection factor in this focal conic condition was stopped to about 4%, and was generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0063] (Refer to the example 4 of an experiment, and drawing 6) In the example 4 of an experiment, 1 micrometer and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 1 micrometer and the inter-electrode spare time S] to 4 micrometers for 10 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.10 and H/D=0.25. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **60V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0064] The planar condition which the reflection factor in this focal conic condition was stopped to about 3%, and was generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0065] In addition, in the example 4 of an experiment, although contrast of an image was not spoiled, the trouble that the width of face L of Electrodes 12a and 12b was disconnected since it is thin, 1 micrometer and occurred. Therefore, lowering of mass production nature is invited to utilization, and becoming disadvantageous in cost is expected. Moreover, the field strength of the horizontal electric field E1 runs short by the same reason, and it is more necessary for [in order to obtain required field strength] for impression of high tension. Therefore, as for the width of face L of Electrodes 12a and 12b, it is desirable that it is larger than 1 micrometer.

[0066] (Refer to the example 5 of an experiment, and drawing 7) In the example 5 of an experiment, 1 micrometer and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 4 micrometers and the inter-electrode spare time S] to 4 micrometers for 20 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.20 and H/D=0.25. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **90V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0067] The planar condition which the reflection factor in this focal conic condition was stopped to about 4%, and was generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0068] In addition, in the example 5 of an experiment, although contrast of an image was not spoiled, in order that the gap S of Electrodes 12a and 12b may obtain 20 micrometers and field strength required for the horizontal electric field E1 since it is large, applied voltage becomes high.

[0069] (Refer to the example 6 of an experiment, and drawing 8) In the example 6 of an

experiment, 1 micrometer and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 4 micrometers and the inter-electrode spare time S] to 4 micrometers for 7 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.57 and H/D=0.25. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **40V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0070] The reflection factor in this focal conic condition was about 9%, and the planar condition generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0071] In addition, in the example 6 of an experiment, the reflection factor in a focal conic condition became higher than said examples 1-5 of an experiment by about 9%. The reason is guessed for the liquid crystal with which the electrode width of face L of Electrodes 12a and 12b will be in a planar condition on electrode 12a and 12b to the inter-electrode spare time S between electrode 12a and 12b since it is large to increase in number a little.

[0072] (Refer to the example 7 of an experiment, and drawing 9) In the example 7 of an experiment, 0.5 micrometers and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 4 micrometers and the inter-electrode spare time S] to 4 micrometers for 10 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.40 and H/D=0.125. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **55V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0073] The reflection factor in this focal conic condition was about 8%, and the planar condition generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0074] In addition, in the example 7 of an experiment, the reflection factor in a focal conic condition became higher than said examples 1-5 of an experiment by about 8%. The reason is guessed for the liquid crystal with which thickness H of Electrodes 12a and 12b will be in a planar condition on electrode 12a and 12b since it is thin, 0.5 micrometers and to increase in number a little.

[0075] (Refer to the example 8 of an experiment, and drawing 10) In the example 8 of an experiment, 3 micrometers and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 4 micrometers and the inter-electrode spare time S] to 4 micrometers for 10 micrometers and electrode thickness H. That is, it was referred to as last shipment=0.40 and H/D=0.75. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **50V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, on electrode 12a and 12b, vertical electric-field E2' occurs slightly, and changes the liquid crystal constituent A of this part into a planar condition.

[0076] The reflection factor in this focal conic condition was about 4%, and the planar condition generated on electrode 12a and 12b was not a thing to the extent that an image display condition (especially contrast) is spoiled.

[0077] In addition, in the example 8 of an experiment, as shown in drawing 10 (B), when generating the vertical electric field E2 and changing liquid crystal to a planar condition, 3 micrometers and since it is thick, as compared with said examples 1-7 of an experiment, a field strength difference (field strength distribution) will become [thickness H of Electrodes 12a and 12b] large on electrode 12a, 12b, and inter-electrode spare time. Consequently, even if liquid crystal changes to a planar condition on electrode 12a and 12b, it will remain a little on inter-electrode spare time with a focal conic condition. Moreover, the thickness of the liquid crystal on electrode 12a and 12b becomes thin by the same reason, even if a planar condition is chosen, as compared with said examples 1-7 of an experiment, the reflection factor in a planar condition becomes low a little, and the whole reflection factor (contrast) falls a little.

[0078] (Refer to the example 1 of comparative experiments, and drawing 11) In the example 1 of comparative experiments, 0.2 micrometers and the cel gap D were set [the electrode width of face L of Electrodes 12a and 12b / 7 micrometers and the inter-electrode spare time S] to 4 micrometers for 5 micrometers and electrode thickness H. That is, it was referred to as last shipment=1.40 and H/D=0.05. First, the electrical potential difference was beforehand impressed between an electrode 22 and Electrodes 12a and 12b, and the liquid crystal constituent A was made into the planar condition. And 100msec impression of the pulse voltage with a frequency of 100Hz of **50V was carried out between electrode 12a and 12b. In this case, the horizontal electric field E1 occur between electrode 12a and 12b, and the liquid crystal constituent A is changed to a focal conic condition. Simultaneously, vertical electric-field E2' occurs on electrode 12a and 12b, and the liquid crystal constituent A of this part is changed into a planar condition.

[0079] The planar condition which the reflection factor in this focal conic condition became about 14%, and was generated on electrode 12a and 12b was a thing to the extent that an image display condition (especially contrast) is spoiled. If the electrode width of face L is as wide as 7 micrometers and Gap S is as narrow as 5 micrometers, although vertical electric-field E2' occurred mostly and has chosen the focal conic condition on electrode 12a and 12b, the liquid crystal of a planar condition will increase in number, and a reflection factor will fall. Moreover, it is the cause that the phenomenon of decline in such a reflection factor also has thickness H of Electrodes 12a and 12b as thin as 0.2 micrometers.

[0080] (Other operation gestalten) in addition, the liquid crystal display concerning this invention is not limited to said each operation gestalt, within the limits of the summary, can be boiled variously and can be changed.

[0081] It can constitute from what was constituted from one layer of the display device shown with said each operation gestalt especially as a display, a thing (full color display) which carried out the laminating of the display device which performs each selective reflection of R, G, and B to three layers, or a thing which carried out the laminating of the display device which performs selective reflection of the wavelength of arbitration to two-layer. Furthermore, the internal configuration of an actuation circuit and its combination are arbitrary.

[0082] Moreover, although the liquid crystal display component of a passive-matrix mold is mentioned as the example with said operation gestalt, also in the liquid crystal display component of the active-matrix mold which has a switching element (for example, TFT:Thin Film Transistor and TFD:Thin Film Diode) for every pixel, this invention is applicable.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The explanatory view showing the principle of operation of liquid crystal.

[Drawing 2] The explanatory view showing the principle of operation of the liquid crystal by the IPS method.

[Drawing 3] With the sectional view showing the liquid crystal display component of the example 1 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 4] With the sectional view showing the liquid crystal display component of the example 2 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 5] With the sectional view showing the liquid crystal display component of the example 3 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 6] With the sectional view showing the liquid crystal display component of the example 4 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 7] With the sectional view showing the liquid crystal display component of the example 5 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 8] With the sectional view showing the liquid crystal display component of the example 6 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 9] With the sectional view showing the liquid crystal display component of the example 7 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 10] With the sectional view showing the liquid crystal display component of the example 8 of an experiment, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 11] With the sectional view showing the liquid crystal display component of the example 1 of comparative experiments, as for (A), (B) shows the time of vertical electric-field impression at the time of horizontal electric-field impression.

[Drawing 12] The perspective view showing the example of an electrode configuration for passive-matrix actuation.

[Description of Notations]

1 -- Liquid crystal display component

11 21 -- Substrate

12a, 12b -- Ctenidium-like electrode

22 -- Counterelectrode

E1 -- Horizontal electric field

E2 -- Vertical electric field

[Translation done.]

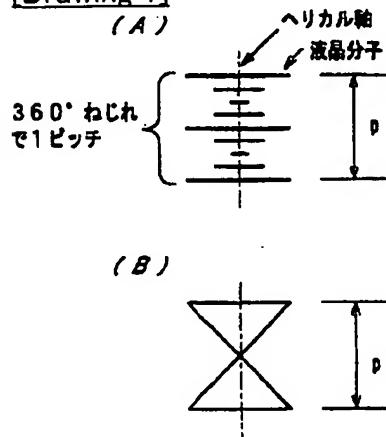
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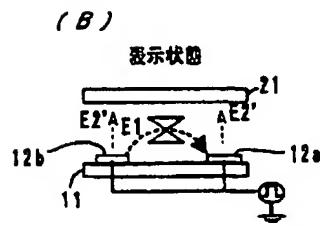
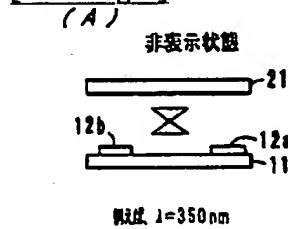
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DRAWINGS

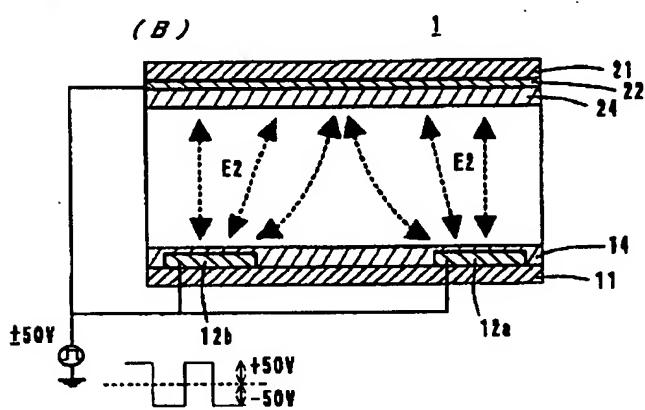
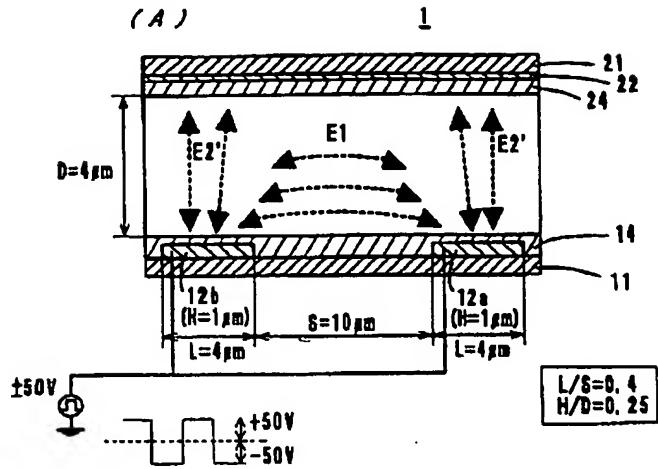
[Drawing 1]



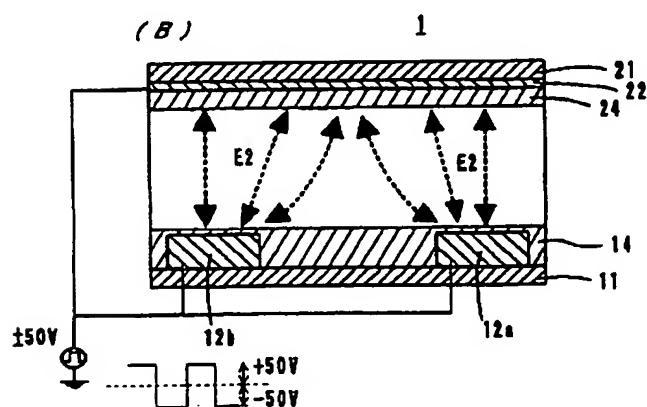
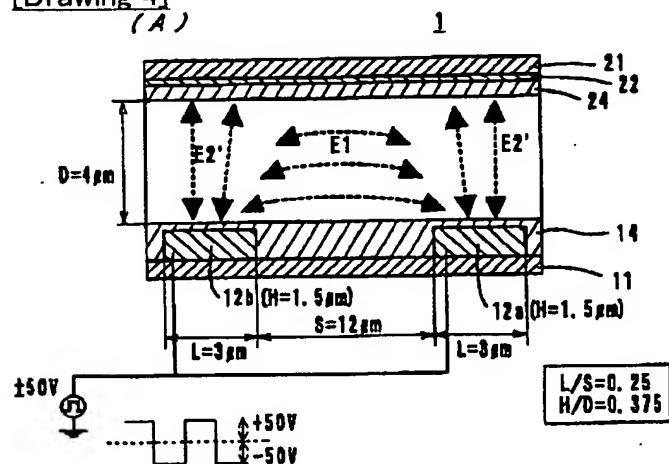
[Drawing 2]



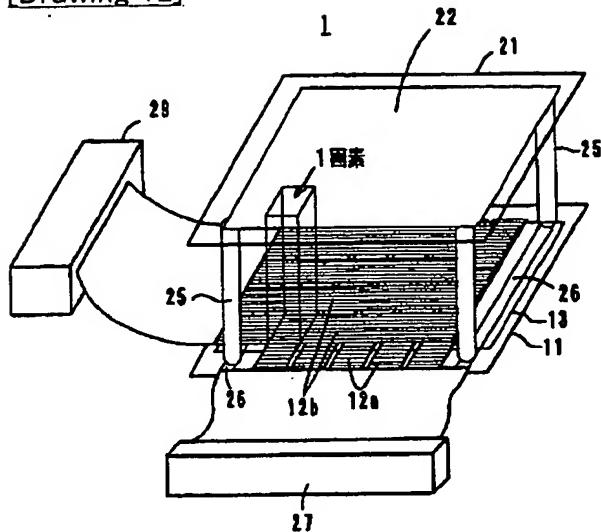
[Drawing 3]



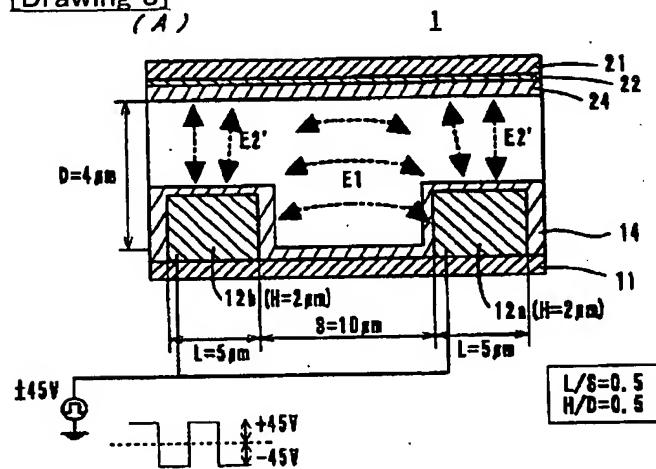
[Drawing 4]



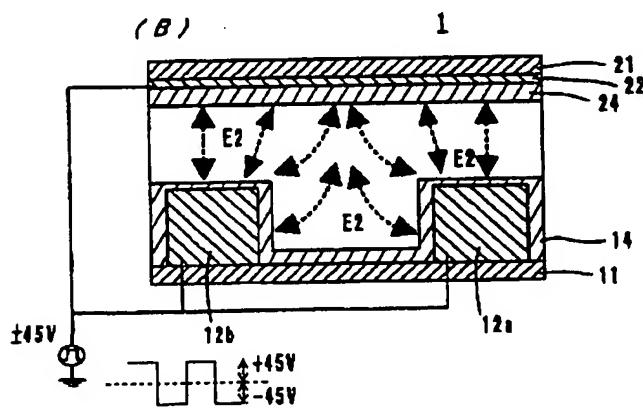
[Drawing 12]



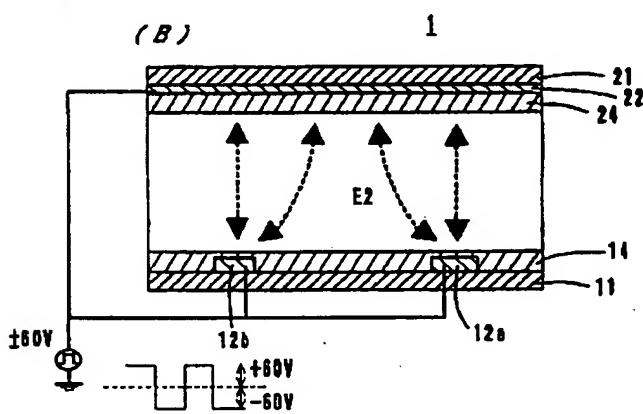
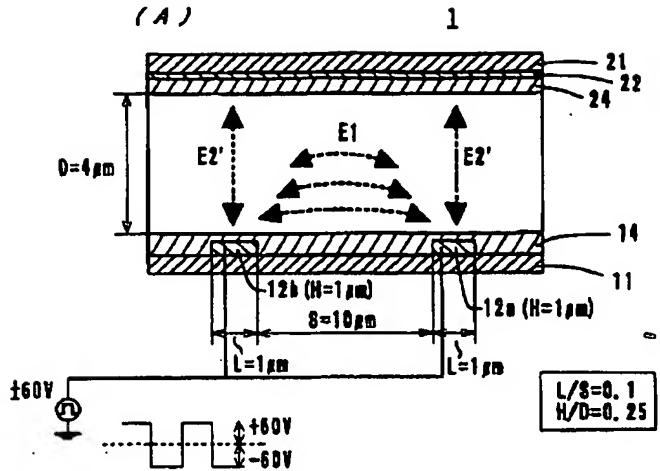
[Drawing 5]



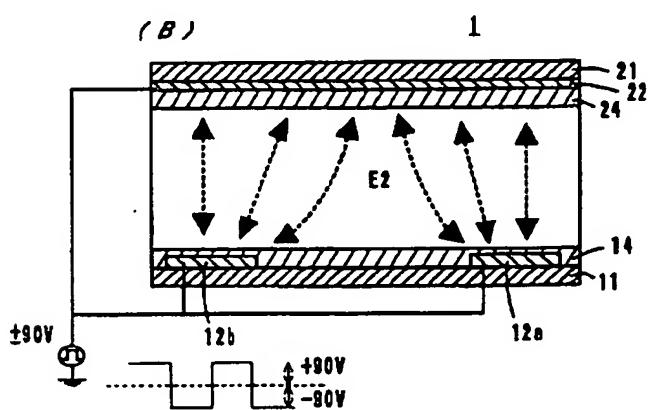
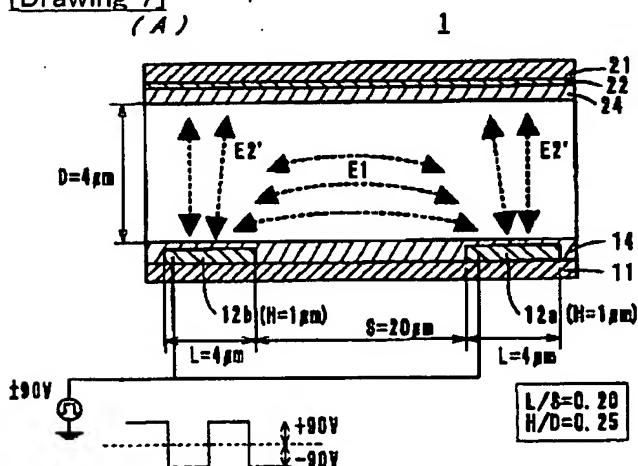
(B)



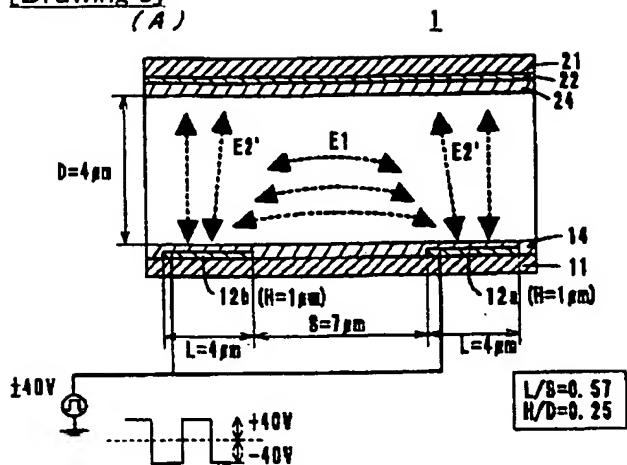
[Drawing 6]



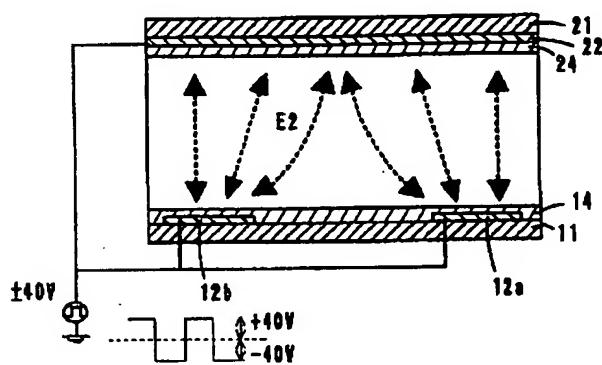
[Drawing 7]



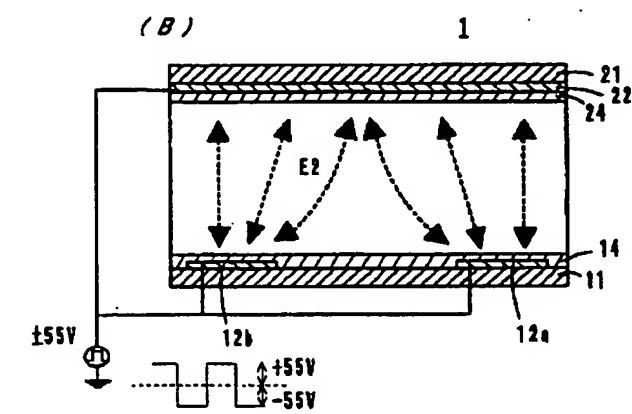
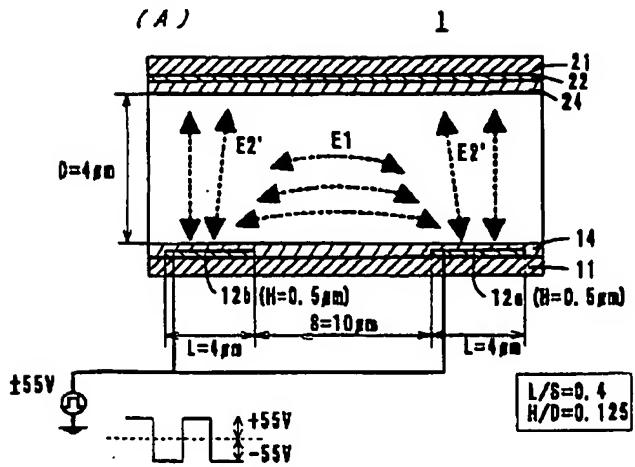
[Drawing 8]



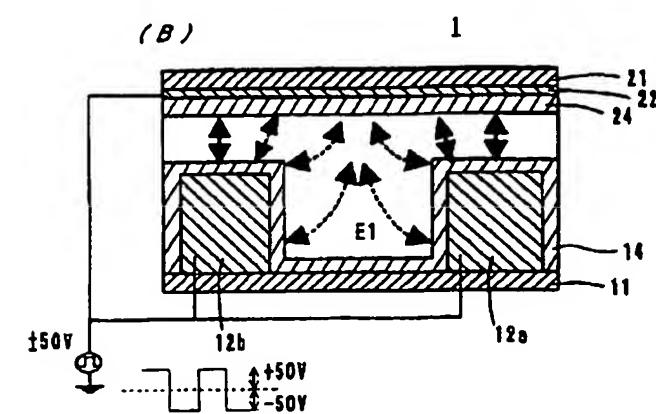
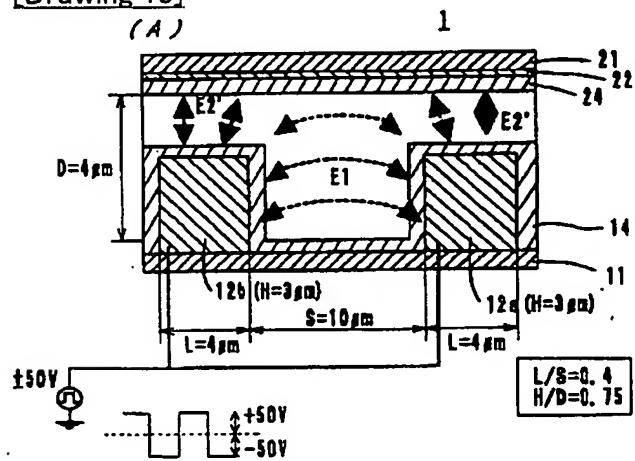
(B)



[Drawing 9]

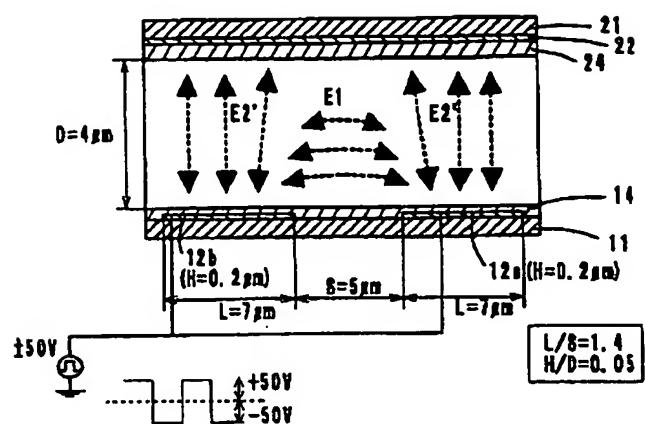


[Drawing 10]



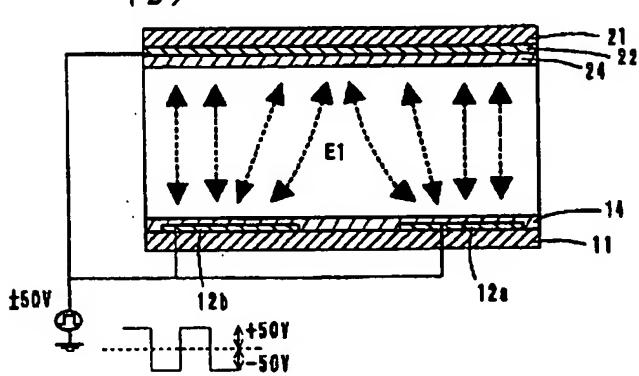
[Drawing 11]

(A)



1

(B)



1

[Translation done.]

(19)日本国特許庁 (JP)

(12) 公開特許公報 (A)

(11)特許出願公開番号
特開2003-172939
(P2003-172939A)

(43)公開日 平成15年6月20日(2003.6.20)

(51)Int.Cl.
G 0 2 F 1/1343

識別記号

F I
G 0 2 F 1/1343

テ-73-ト[®](参考)
2 H 0 9 2

(21)出願番号 特願2001-373438(P2001-373438)
(22)出願日 平成13年12月6日(2001.12.6)

審査請求 未請求 請求項の数5 OL (全13頁)

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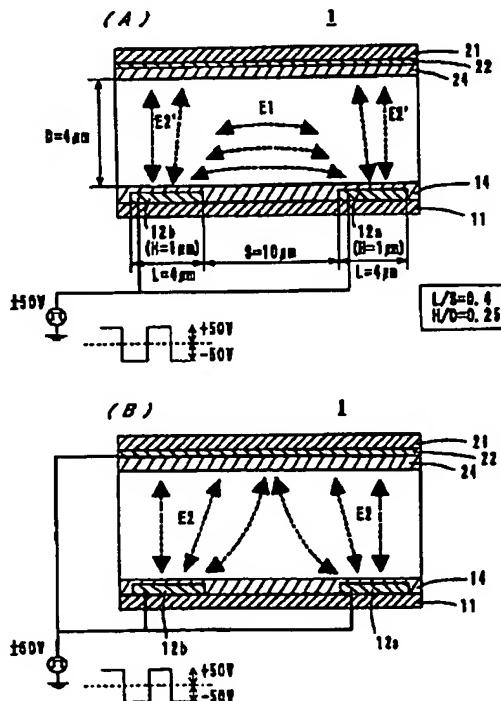
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(54)【発明の名称】 液晶表示装置

(57)【要約】

【課題】 画像のコントラストを高めることのできる液晶表示装置を得る。

【解決手段】 極歯状電極12a, 12bを備えた基板11と平面電極22を備えた基板21との間にカイラルネマチック液晶を挟持し、該液晶の選択反射を利用して表示を行う液晶表示装置。電極12a, 12bの電極幅をLとし、電極間隙をSとしたときに、 $0.1 \leq L/S \leq 0.6$ である。 $1 \mu\text{m} < L \leq 5 \mu\text{m}$ 、かつ、 $6 \mu\text{m} \leq S \leq 20 \mu\text{m}$ であることが好ましい。また、電極12a, 12bの電極厚みをHとし、セルギャップをDとしたときに、 $0.1 < H/D < 1$ である。このような条件に設定すると、横電界E1を発生させた際に電極12a, 12b上での縦電界E2'の発生を極力抑えることができる。



【特許請求の範囲】

【請求項1】 一対の基板と、該基板間に挟持されたコレステリック相を示す液晶と、少なくとも基板に対してほぼ平行方向の電界を印加する電極と、を備え、少なくとも一方の基板には櫛歯状の電極が形成されており、該櫛歯状電極の電極幅をL、電極間隙をSとしたときに、 $0.1 \leq L/S \leq 0.6$ であること、を特徴とする液晶表示装置。

【請求項2】 前記櫛歯状電極は、 $1 \mu\text{m} < L \leq 5 \mu\text{m}$ 及び／又は $6 \mu\text{m} \leq S \leq 20 \mu\text{m}$ であることを特徴とする請求項1記載の液晶表示装置。

【請求項3】 一対の基板と、該基板間に挟持されたコレステリック相を示す液晶と、少なくとも基板に対してほぼ平行方向の電界を印加する電極と、を備え、少なくとも一方の基板には櫛歯状の電極が形成されており、該櫛歯状電極の電極厚みをH、前記基板間のギャップをDとしたときに、 $0.1 < H/D < 1$ であること、を特徴とする液晶表示装置。

【請求項4】 一対の基板と、該基板間に挟持されたコレステリック相を示す液晶と、少なくとも基板に対してほぼ平行方向の電界を印加する電極と、を備え、少なくとも一方の基板には櫛歯状の電極が形成されており、該櫛歯状電極の電極幅をL、電極間隙をS、電極厚みをH、前記基板間のギャップをDとしたときに、 $0.1 \leq L/S \leq 0.6$ 、かつ、 $0.1 < H/D < 1$ であること、を特徴とする液晶表示装置。

【請求項5】 前記液晶がメモリ性を有することを特徴とする請求項1、請求項2、請求項3又は請求項4記載の液晶表示装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、液晶表示装置、特に、一対の基板間にコレステリック相を示す液晶を挟持し、該液晶の選択反射を利用して表示を行う液晶表示装置に関する。

【0002】

【従来技術と課題】従来、コレステリック液晶やコレステリック液晶相を示すカイラルネマチック液晶を一対の基板間に挟持し、基板面に対して平行方向の横電界を印加し、液晶の状態を変化させて表示を行う液晶表示装置が提案されている（例えば、特開平7-120792号公報、特開2001-83485号公報参照）。横電界の印加時に縦電界を重疊する例もある（特開2001-100256号公報参照）。

【0003】ところで、横電界の印加によって液晶の状態を変化させて画像を表示するコレステリック相を示す液晶を用いた従来の液晶表示装置においては、横電界を発生させるために、少なくとも一方の基板に配置される電極を櫛歯状にしていた。この櫛歯状電極間に電位差を

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生じさせると横電界が発生するが、このときに櫛歯状電極上に存在する液晶を意図するようにスイッチングされられず、その結果、電極上の液晶が表示を阻害する状態になり、画像のコントラストが低下するという問題点を有していた。

【0004】そこで、本発明の目的は、基板に対して平行な横電界を発生させた際に電極上に存在する制御できない液晶領域の発生を極力抑えて画像のコントラストを高めることのできる液晶表示装置を提供することにある。

【0005】

【発明の構成、作用及び効果】以上の目的を達成するため、第1の発明に係る液晶表示装置は、一対の基板と、該基板間に挟持されたコレステリック相を示す液晶と、少なくとも基板に対してほぼ平行方向の電界を印加する電極と、を備え、少なくとも一方の基板には櫛歯状の電極が形成されており、櫛歯状電極の電極幅をLとし、電極間隙をSとしたときに、 $0.1 \leq L/S \leq 0.6$ であることを特徴とする。さらに、前記櫛歯状電極は、 $1 \mu\text{m} < L \leq 5 \mu\text{m}$ 及び／又は $6 \mu\text{m} \leq S \leq 20 \mu\text{m}$ であることが好ましい。

【0006】第2の発明に係る液晶表示装置は、一対の基板と、該基板間に挟持されたコレステリック相を示す液晶と、少なくとも基板に対してほぼ平行方向の電界を印加する電極と、を備え、少なくとも一方の基板には櫛歯状の電極が形成されており、櫛歯状電極の電極厚みをHとし、前記基板間のギャップをDとしたときに、 $0.1 < H/D < 1$ であることを特徴とする。

【0007】一般に、コレステリック相を示す液晶は所定の電圧を印加すると、誘電率異方性が正の液晶にあってはそのヘリカル軸が電界方向と直交する方向に変化し、誘電率異方性が負の液晶にあってはそのヘリカル軸が電界方向に平行な方向に変化する。この場合、基板面に対して垂直方向あるいは平行方向に選択的に電界を発生させることで、液晶はヘリカル軸が基板に対してほぼ垂直方向及び水平方向に変化し、かつ、コレステリック相を保つことで、各画素をブレーナ状態又はフォーカルコニック状態に設定して画像を表示する。

【0008】本発明者は、基板に対してほぼ平行方向の横電界を印加する櫛歯状電極の電極幅L、電極間隙S、電極厚みH及び基板間のギャップDをパラメータとし、これらのパラメータを種々の値に変化させて実験を行った結果、横電界を発生させた際に電極の直上に発生する制御不能な液晶領域を減少させ、電極上の液晶が表示を阻害する状態になることを極力防止でき、コントラストが向上する条件を解明し、本発明に至った。

【0009】即ち、電極幅Lと電極間隙Sとの関係においては、 $0.1 \leq L/S \leq 0.6$ の条件下で好ましいコントラストを得ることができ、特に、電極幅Lが $1 \mu\text{m} < L \leq 5 \mu\text{m}$ 、かつ、電極間隙Sが $6 \mu\text{m} \leq S \leq 20 \mu\text{m}$

Ⅲであるときにより好ましいコントラストを得ることができた。より好ましくは、 $0.25 \leq L/S \leq 0.5$ とする。

【0010】また、電極厚みHと基板間ギャップDとの関係においては、 $0.1 < H/D < 1$ の条件下で好ましいコントラストを得ることができた。より好ましくは、 $0.2 \leq H/D < 0.7$ とする。

【0011】液晶表示装置が、前記第1の発明と第2の発明とを兼ね備えた構成であってもよい。両者を兼ね備えていると、コントラストの向上により効果的である。また、液晶がメモリ性を有するものを使用すれば、省電力化を図ることができ、携帯端末に適したものになる。

【0012】

【発明の実施の形態】以下、本発明に係る液晶表示装置の実施形態について、添付図面を参照して説明する。

【0013】(駆動原理、図1、2参照)本発明に係る液晶表示装置は、種々の駆動原理に基づいて表示を行うものであり、その代表的な駆動原理として、縦横電界切換え方式とIPS(In-Plane-Switching)方式について説明する。

【0014】縦横電界切換え方式は、縦電界を印加する手段及び横電界を印加する手段を備え、両者の切り換えによりコレステリック相を示す液晶(以下、カイラルネマチック液晶で代表する)のねじれを完全に解くことなく、そのヘリカル軸を基板に対して所定の角度に、好ましくは、基板に対してほぼ垂直及びほぼ平行に変化させることにより表示を行うものである。

【0015】カイラルネマチック液晶はネマチック液晶に所定量のカイラル材を添加することによって得られる。このカイラルネマチック液晶は、図1(A)に示すように、一般的に、棒状の液晶分子がねじれた配列をなし、コレステリック相を示している。この液晶に光が入射すると、ヘリカル軸に対して平行な方向から光が入射した場合、 $\lambda = n_p$ で示される波長の光を選択反射する(ブレーナ状態)。ここで、 λ は波長、nは液晶分子の平均屈折率、pは液晶分子が 360° ねじれている距離(以下、螺旋ピッチと記す)である。一方、ヘリカル軸に対して垂直な方向から光が入射した場合、光は散乱される(フォーカルコニック状態)。ブレーナ状態での選択反射波長が可視光領域に設定されている場合はフォーカルコニック状態での散乱が弱くなり実質的に入射光を透過する。この選択反射及び散乱(透過)を利用して表示が行われる。なお、液晶のコレステリック相は図1(B)のようにも示される。

【0016】ところで、液晶分子は棒状であるが、その長手方向(長軸)とそれに垂直な方向(短軸)で屈折率や誘電率が異なる異方性を有している。液晶分子の長軸方向の屈折率及び誘電率が短軸方向のそれよりも大きい液晶を誘電率異方性が正の液晶と称する。誘電率異方性が正の液晶に十分に高い電圧を印加するとねじれが解

け、液晶分子の長軸(誘電率が大きい軸)が電界方向と平行な方向に向くように動く。このねじれが解ける電圧には閾値が存在し、この閾値電圧をV_hとする。

【0017】また、前記閾値電圧V_hよりも低い電圧を液晶に印加すると、液晶はねじれを解くことなくヘリカル軸が電界方向に対して垂直な方向に向くように動く。このヘリカル軸を動かす電圧にも閾値が存在し、この閾値電圧をV_fとする。

【0018】これらの閾値電圧V_h、V_fの関係は、 $V_f < V_h$ である。また、閾値電圧V_fよりも低い電圧を液晶に印加しても液晶分子は動くことがない、即ち、ヘリカル軸方向が変化することがない。

【0019】これに対して、液晶分子の長軸方向の屈折率が短軸方向のそれよりも大きく、かつ、長軸方向の誘電率が短軸方向のそれよりも小さい液晶を誘電率異方性が負の液晶と称する。誘電率異方性が負の液晶に十分に高い電圧を印加するとねじれを解くことなくヘリカル軸が電界方向とは関係なくランダムに向く。この現象はダイナミックスキャッタリングと称されている。この現象が起こる電圧には閾値が存在し、閾値電圧をV_dとする。

【0020】また、前記閾値電圧V_dよりも低い電圧を液晶に印加すると、液晶はねじれを解くことなくヘリカル軸が電界方向に対して平行な方向に向くように動く。このヘリカル軸を動かす電圧にも閾値が存在し、この閾値電圧をV_pとする。

【0021】これらの閾値電圧V_d、V_pの関係は、 $V_p < V_d$ である。また、閾値電圧V_pよりも低い電圧を液晶に印加しても液晶分子は動くことがない、即ち、ヘリカル軸方向が変化することがない。

【0022】一方、IPS方式は、基板に対して平行な横電界を印加することによって表示を行う方式であり、一例として以下のようないわゆる形態がある。即ち、図2(A)に示すように、波長入が350nm程度になるように螺旋ピッチpを調整した誘電率異方性が正のカイラルネマチック液晶を基板11、21間に挟持しておく。電極12a、12b間に電圧を印加しない状態では、ヘリカル軸が基板面に垂直なブレーナ状態を保持するが、波長入が短いために選択反射光は目視されず、非表示状態である。

【0023】ここで、図2(B)に示すように、電極12a、12b間に横電界E1を発生させると、液晶は電界強度(電圧)に応じて螺旋ピッチ(螺旋が解かれる量)が変化する。例えば、波長入が470nmになるように螺旋ピッチpを制御すると青色の光が選択反射され、550nmに制御すると緑色の光が選択反射され、660nmに制御すると赤色の光が選択反射される。これ以外にも電圧無印加時(このときに縦電界が重畠されているよい)には選択反射、電圧印加時に透過とすることで表示を行う形態もある。

【0024】(実施形態、図3～10参照)図3～10は以下に説明する実験例1～8で使用された液晶セルであって1単位の画素の数分の1～十数分の1を概略的に示している。そこで、図3～10を参照して一実施形態である液晶表示素子1について説明する。

【0025】この液晶表示素子1は、下側の基板11に電極12a、12b及び配向制御膜14を設け、上側の基板21に電極22及び配向制御膜24を設け、基板11、21間にネマチック液晶にカイラル材を添加して室温でコレステリック相を示すように調製したカイラルネマチック液晶を挟持した構成からなる。

【0026】液晶としては、室温でコレステリック相を示すものであれば、種々のものを使用することができる。誘電率異方性については正負いずれのものであってもよい。

【0027】基板11、21の材料は、ガラスやポリエーテルスルфон(PES)、ポリエチレンテレフタレート(PET)、ポリカーボネート(PC)等のプラスチックフィルムなど種々のものを使用できる。軽量で薄いものが好ましい。電極12a、12b、22の材料は、ITO、IZO等の透明電極材料を使用でき、下側基板11の電極12a、12bにはA1、Cu等の非透明電極材料を使用してもよい。電極12a、12bは絶縁膜13(図12参照)を介して2段に配置してもよい。配向制御膜14、24は電極12a、12b、22を覆うように設けられている。絶縁膜13や配向制御膜14、24は従来公知の材料を用いることができる。

【0028】なお、電極12a、12bは各図3～11の紙面と直交する方向に延在し、かつ、紙面の左右方向に交互に並べて配置された櫛歯状の電極である。電極22は少なくとも1画素分の幅を有する各図3～11の左右方向に延在する電極であり、画像表示面の全体を被覆する全面電極であってもよい。

【0029】さらに、基板11、21間のギャップを均一で一定に保持するために、必要に応じて、基板11、21間にスペーサ用の微粒子や、柱状又は壁状の樹脂構造物が配置される。また、下側の基板11の裏面に可視光を吸収する光吸収層が設けられる。基板11自体に可視光吸収機能を持たせてよい。

【0030】また、基板11、21の周囲にはシール材を設けて基板間に液晶を封止することが好ましい。なお、配向制御膜14に対するラビング処理は原理的に不要であるが、密度の低いラビング処理(例えば、ラビング密度10以下)や部分的なラビング処理を行って、液晶のプレーナ状態での反射率を高めるようにしてもよい。配向制御膜14自体を省略してもよい。

【0031】以上の構成からなる液晶表示素子1において、正の誘電率異方性を有するカイラルネマチック液晶にあっては、基板11側に設けられた電極12a、12b間にVhより低くVf以上の電圧差を生じるように駆

動すると、図3(A)に示すように、基板面に平行な横電界E1が発生し、液晶のヘリカル軸が基板面にほぼ垂直な方向に向く。即ち、液晶はプレーナ状態になり、所定波長の選択反射が生じる。

【0032】一方、電極12a及び/又は12bと電極22との間にVhより低くVf以上の電圧差を生じるよう駆動すると、図3(B)に示すように、基板面に垂直な縦電界E2が発生し、液晶のヘリカル軸が基板面に平行な方向に向く。即ち、液晶はフォーカルコニック状態になり、光を透過する。

【0033】また、負の誘電率異方性を有するカイラルネマチック液晶にあっては、そのヘリカル軸が電界方向に対して平行になるように動くため、電極12a、12b間にVdより低くVp以上の電圧差を生じるように駆動すると、液晶はヘリカル軸が基板面に平行な方向に向き、フォーカルコニック状態になる。一方、電極12a及び/又は12bと電極22との間にVdより低くVp以上の電圧差を生じるように駆動すると、液晶はヘリカル軸が基板面にほぼ垂直な方向に向き、プレーナ状態になる。

【0034】図3(A)～図11(A)に示されているように、電極12a、12b間に電位差を生じさせて横電界E1を発生させると、同時に電極12a、12b上には縦電界E2'が発生し、この縦電界E2'によって液晶が部分的に横電界E1とは異なる状態となって表示を阻害し、画像のコントラストが低下する。また、IPS方式にあっても、図2(B)に示すように、縦電界E2'が発生して表示を阻害する状態になり、改善が必要である。

【0035】縦電界E2'の影響を十分抑制するためには、下記式(1)又は式(2)のいずれかの関係を満たすようにする。即ち、櫛歯状電極の電極幅をL、電極間隙をS、電極厚みをH、基板間ギャップ(以下、セルギャップとも記す)をDとしたときに、

$$0.1 \leq L/S \leq 0.6 \quad \dots \dots (1)$$

$$0.1 < H/D < 1 \quad \dots \dots (2)$$

とする。

【0036】ここで、L/S < 0.1であると、横電界E1の電界強度不足により高電圧を印加することが必要になる。また、L/S > 0.6であると、フォーカルコニック状態選択時の反射率が高くなりすぎてコントラストが低下する。L/Sの範囲を0.25 ≤ L/S ≤ 0.5とすることがより好ましい。

【0037】電極幅しが1μm以下の場合、電極が細いために断線が多くなり、量産率が低下し、生産コストが上昇する。また、電極幅しが5μmより大きい場合、フォーカルコニック状態選択時の反射率が高くなりすぎてコントラストが低下する。このような観点から、1μm < L ≤ 5μmとすることが好ましい。

【0038】電極間隙Sが6μm未満の場合、フォーカ

ルコニック状態選択時の反射率が高くなりすぎて、コントラストが低下する。また、電極間隙Sが $20\mu m$ を超える場合、横電界E 1の電界強度不足により高電圧を印加することが必要になる。このような観点から、 $6\mu m \leq S \leq 20\mu m$ とすることが好ましい。

【0039】一方、H/Dが0.1以下の場合、フォーカルコニック状態選択時の反射率が高くなりすぎて、コントラストが低下する。H/Dが1の場合、電極が対向基板側に達してしまい、短絡等を生じるおそれがある。H/Dの範囲を $0.2 \leq H/D < 0.7$ とすることがより好ましい。

【0040】電極厚みHは、成膜やエッティング等の加工技術の点から $10\mu m$ 以下が好ましい。また、電極が薄すぎると横電界で制御できない液晶領域が増えすぎるおそれがあるので、少なくとも $0.5\mu m$ 以上とすることが好ましい。

【0041】基板間ギャップDは、あまり大きくなるとフォーカルコニック状態選択時の透過率の低下や駆動電圧の高電圧化が懸念されるため $10\mu m$ 以下が望ましい。また、基板間ギャップDが小さすぎると十分なコントラストがとれないおそれがあるので、少なくとも $2\mu m$ 以上とすることが好ましい。

【0042】(単純マトリクス駆動用の電極構成例と駆動方法、図12参照)ここで、前記実施形態において、基板11, 21に設けられる電極12a, 12b, 22の一構成例を図12に示し、併せて駆動方法について説明する。

【0043】基板11に設けた走査電極12aは1画素の一辺の大きさに対応する長さの微細な歯状電極として形成され、信号電極12bは1画素の他辺の大きさに対応してグループ分けされた微細な歯状電極として形成されている。基板21に設けたリセット電極22は画像表示領域に対応する全面電極として形成されている。

【0044】リセット電極22はコンタクトライン25, 26を介して走査信号/リセット信号駆動回路27に接続されている。この走査信号/リセット信号駆動回路27には走査電極12aも接続されている。また、信号電極12bはデータ信号駆動回路29に接続されている。

【0045】表示を新たに書き込む場合や更新する場合には、正の誘電率異方性を有するカイラルネマチック液晶を対象とすると、まず、走査電極12aとリセット電極22との間にVhより低くVf以上の電圧差を生じさせる。これにて、液晶のヘリカル軸が基板面に平行な方向に向き、全画素の液晶がフォーカルコニック状態にリセットされる。

【0046】次に、画像を書き込む画素に対して、走査電極12aと信号電極12bとの間にVhより低くVf以上の電圧差を生じさせる。これにて、液晶のヘリカル軸が基板面にほぼ垂直な方向に向き、電圧が印加された

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画素の液晶のみがブレーナ状態に変化する。この画像書き込み駆動は、走査電極12aを1ラインずつ選択しながら信号電極12bへ画像データに基づいてパルス信号を付与する単純マトリクス駆動方式による。

【0047】一方、負の誘電率異方性を有するカイラルネマチック液晶を対象とする場合には、まず、走査電極12aとリセット電極22との間にVdより低くVp以上の電圧差を生じさせて全ての画素の液晶をブレーナ状態にリセットする。その後、走査電極12aと信号電極12bとの間にVdより低くVp以上の電圧差を生じさせ、走査電極12aに沿って1ラインずつ所定の画素の液晶をフォーカルコニック状態にセットしていくことになる。

【0048】なお、単純マトリクス駆動の場合、駆動対象となっていない画素(液晶)に対しても駆動回路から供給される電圧(クロストーク電圧)が印加される。しかし、このクロストーク電圧を閾値電圧Vf, Vpより低く抑えれば、液晶の状態が変化することはない。

【0049】ところで、図12に示した電極構成例では、前述した一括りセット方式で駆動する以外に、走査電極12aを画素の1ラインずつ複数本あるいは複数ラインを同時にリセットしてからヘリカル軸を目的とする方向に変化させる分割リセット方式で駆動することもできる。また、リセットされることなく各画素ごとにヘリカル軸を目的の方向にセットしていく個別駆動方式でも駆動可能である。

【0050】(電界付与の諸態様)液晶のヘリカル軸方向を変化させるために付与される電界は、電極に印加する電位を制御することにより、方向や強度を調整することができる。前記実施形態では、横電界E 1及び縦電界E 2を発生させる3極構成の電極を示したが、本発明に係る液晶表示装置として採用できる電極構成は3極に限定するものではない。例えば、図3~10に示す基板11を2枚対向させて液晶セルとし、電極12a, 12bによる4極構成としてもよい。

【0051】また、図2に示したIPS方式にあっては、基板11上にのみ電極12a, 12bを形成し、基板21には電極を形成しない構成が採用される。横電界印加時に縦電界を重畳するための電極が基板21に設けられていてもよい。

【0052】(実験例の説明)本発明者らは、電極12a, 12bの電極幅L、電極間隙S、電極厚みH及び基板11, 21間のギャップDをパラメータとし、これらのパラメータを種々の値に変化させ、電極12a, 12b間に電圧を印加して横電界E 1を発生させたときの反射率を測定し、電極12a, 12b上に発生する縦電界E 2'が減少する条件を解明した。その結果を以下に説明する。

【0053】以下の実験例1~8及び比較実験例1の全てにおいて、カイラルネマチック液晶としては、液晶性

化合物Z L I - 2806 (メルク社製) 80重量部に、カイラル材CB-15、R-1011 (いずれもメルク社製) をそれぞれ16重量部、4重量部添加し、負の誘電率異方性を有し、選択反射のピーク波長が約630nmである液晶組成物Aを調製した。

【0054】従って、電極12a、12b間に電位差を生じさせて横電界E1を発生させると、液晶組成物Aはフォーカルコニック状態になる。また、プレーナ状態を選択する場合には、電極12a、12bの少なくともいずれかと電極22との間に電位差を生じさせ、縦電界E2を発生させればよい。なお、前記液晶組成物は、プレーナ状態、フォーカルコニック状態、及び両者の混在した状態を電圧無印加状態で保つことができる特性(メモリ性)を有する。

【0055】また、実験例1～8及び比較実験例1として以下の材料、方法で液晶パネルを製作した。即ち、ポリカーボネートフィルムからなる基板11にITO膜を形成し、フォトリソグラフィ法で電極12a、12bをバターニングした。配向制御膜14はJSR社製:2022を用いてフレキソ印刷により形成した。一方、ポリカーボネートフィルムからなる基板21にITO膜を形成し、フォトリソグラフィ法で電極22を設けた。配向制御膜24はJSR社製:2022を用いてフレキソ印刷により形成した。

【0056】前記基板11、21は、前記液晶組成物A及びギャップ保持部材を挟持した状態に貼り合わせた。ギャップ保持部材には、基板間隔が狭くなるのを防止するため球状スペーサーを用い、基板間隔が広がるのを防止するためにウレタン系の接着剤を用いて、スペーサ径より若干高い高さの柱状樹脂構造物を格子状に配置した。また、基板の周縁部をシール材によって封止した。なお、スペーサーはセルギャップDの寸法に合わせた粒径のものを使用した。

【0057】(実験例1、図3参照)実験例1では、電極12a、12bの電極幅Lを4μm、電極間隙Sを10μm、電極厚みHを1μm、セルギャップDを4μmとした。即ち、L/S=0.40、H/D=0.25とした。まず、予め電極22と電極12a、12bとの間に電圧を印加して液晶組成物Aをプレーナ状態とした。そして、電極12a、12b間に周波数100Hzの±50Vのパルス電圧を100ms印加した。この場合、電極12a、12b間に横電界E1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a、12b上に縦電界E2'が僅かに発生し、この部分の液晶組成物Aをプレーナ状態にする。

【0058】このフォーカルコニック状態での反射率は約4%に抑えられ、電極12a、12b上に発生したプレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0059】(実験例2、図4参照)実験例2では、電

極12a、12bの電極幅Lを3μm、電極間隙Sを12μm、電極厚みHを1.5μm、セルギャップDを4μmとした。即ち、L/S=0.25、H/D=0.375とした。まず、予め電極22と電極12a、12bとの間に電圧を印加して液晶組成物Aをプレーナ状態とした。そして、電極12a、12b間に周波数100Hzの±50Vのパルス電圧を100ms印加した。この場合、電極12a、12b間に横電界E1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a、12b上に縦電界E2'が僅かに発生し、この部分の液晶組成物Aをプレーナ状態にする。

【0060】このフォーカルコニック状態での反射率は約3.5%に抑えられ、電極12a、12b上に発生したプレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0061】(実験例3、図5参照)実験例3では、電極12a、12bの電極幅Lを5μm、電極間隙Sを10μm、電極厚みHを2μm、セルギャップDを4μmとした。即ち、L/S=0.50、H/D=0.50とした。まず、予め電極22と電極12a、12bとの間に電圧を印加して液晶組成物Aをプレーナ状態とした。そして、電極12a、12b間に周波数100Hzの±45Vのパルス電圧を100ms印加した。この場合、電極12a、12b間に横電界E1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a、12b上に縦電界E2'が僅かに発生し、この部分の液晶組成物Aをプレーナ状態にする。

【0062】このフォーカルコニック状態での反射率は約4%に抑えられ、電極12a、12b上に発生したプレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0063】(実験例4、図6参照)実験例4では、電極12a、12bの電極幅Lを1μm、電極間隙Sを10μm、電極厚みHを1μm、セルギャップDを4μmとした。即ち、L/S=0.10、H/D=0.25とした。まず、予め電極22と電極12a、12bとの間に電圧を印加して液晶組成物Aをプレーナ状態とした。そして、電極12a、12b間に周波数100Hzの±60Vのパルス電圧を100ms印加した。この場合、電極12a、12b間に横電界E1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a、12b上に縦電界E2'が僅かに発生し、この部分の液晶組成物Aをプレーナ状態にする。

【0064】このフォーカルコニック状態での反射率は約3%に抑えられ、電極12a、12b上に発生したプレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0065】なお、実験例4では、画像のコントラストを損なうものではなかったが、電極12a、12bの幅

Lが $1\text{ }\mu\text{m}$ と細いために断線するという問題点が発生した。そのため、実用化には量産性の低下を招来し、コスト的に不利になることが予想される。また、同じ理由で横電界E 1の電界強度が不足し、必要な電界強度を得るためにより高電圧の印加が必要にもなる。そのため、電極12a, 12bの幅Lは $1\text{ }\mu\text{m}$ よりも広いことが好ましい。

【0066】(実験例5、図7参照)実験例5では、電極12a, 12bの電極幅Lを $4\text{ }\mu\text{m}$ 、電極間隙Sを $2\text{ }\mu\text{m}$ 、電極厚みHを $1\text{ }\mu\text{m}$ 、セルギャップDを $4\text{ }\mu\text{m}$ とした。即ち、 $L/S=0.20$ 、 $H/D=0.25$ とした。まず、予め電極22と電極12a, 12bとの間に電圧を印加して液晶組成物Aをブレーナ状態とした。そして、電極12a, 12b間に周波数 100 Hz の± 90 V のパルス電圧を 100 msec 印加した。この場合、電極12a, 12b間に横電界E 1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a, 12b上に縦電界E 2'が僅かに発生し、この部分の液晶組成物Aをブレーナ状態にする。

【0067】このフォーカルコニック状態での反射率は約4%に抑えられ、電極12a, 12b上に発生したブレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0068】なお、実験例5では、画像のコントラストを損なうものではなかったが、電極12a, 12bの間隙Sが $20\text{ }\mu\text{m}$ と広いために横電界E 1に必要な電界強度を得るために印加電圧が高くなる。

【0069】(実験例6、図8参照)実験例6では、電極12a, 12bの電極幅Lを $4\text{ }\mu\text{m}$ 、電極間隙Sを $7\text{ }\mu\text{m}$ 、電極厚みHを $1\text{ }\mu\text{m}$ 、セルギャップDを $4\text{ }\mu\text{m}$ とした。即ち、 $L/S=0.57$ 、 $H/D=0.25$ とした。まず、予め電極22と電極12a, 12bとの間に電圧を印加して液晶組成物Aをブレーナ状態とした。そして、電極12a, 12b間に周波数 100 Hz の± 40 V のパルス電圧を 100 msec 印加した。この場合、電極12a, 12b間に横電界E 1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a, 12b上に縦電界E 2'が僅かに発生し、この部分の液晶組成物Aをブレーナ状態にする。

【0070】このフォーカルコニック状態での反射率は約9%であり、電極12a, 12b上に発生したブレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0071】なお、実験例6では、フォーカルコニック状態での反射率が約9%で前記実験例1~5よりも高くなかった。その理由は、電極12a, 12bの電極幅Lが電極12a, 12b間の電極間隙Sに対して大きいために、電極12a, 12b上でブレーナ状態となる液晶が若干多くなるためと推測される。

【0072】(実験例7、図9参照)実験例7では、電

極12a, 12bの電極幅Lを $4\text{ }\mu\text{m}$ 、電極間隙Sを $10\text{ }\mu\text{m}$ 、電極厚みHを $0.5\text{ }\mu\text{m}$ 、セルギャップDを $4\text{ }\mu\text{m}$ とした。即ち、 $L/S=0.40$ 、 $H/D=0.125$ とした。まず、予め電極22と電極12a, 12bとの間に電圧を印加して液晶組成物Aをブレーナ状態とした。そして、電極12a, 12b間に周波数 100 Hz の± 55 V のパルス電圧を 100 msec 印加した。この場合、電極12a, 12b間に横電界E 1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a, 12b上に縦電界E 2'が僅かに発生し、この部分の液晶組成物Aをブレーナ状態にする。

【0073】このフォーカルコニック状態での反射率は約8%であり、電極12a, 12b上に発生したブレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0074】なお、実験例7では、フォーカルコニック状態での反射率が約8%で前記実験例1~5よりも高くなかった。その理由は、電極12a, 12bの厚みHが $0.5\text{ }\mu\text{m}$ と薄いために、電極12a, 12b上でブレーナ状態となる液晶が若干多くなるためと推測される。

【0075】(実験例8、図10参照)実験例8では、電極12a, 12bの電極幅Lを $4\text{ }\mu\text{m}$ 、電極間隙Sを $10\text{ }\mu\text{m}$ 、電極厚みHを $3\text{ }\mu\text{m}$ 、セルギャップDを $4\text{ }\mu\text{m}$ とした。即ち、 $L/S=0.40$ 、 $H/D=0.75$ とした。まず、予め電極22と電極12a, 12bとの間に電圧を印加して液晶組成物Aをブレーナ状態とした。そして、電極12a, 12b間に周波数 100 Hz の± 50 V のパルス電圧を 100 msec 印加した。この場合、電極12a, 12b間に横電界E 1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a, 12b上に縦電界E 2'が僅かに発生し、この部分の液晶組成物Aをブレーナ状態にする。

【0076】このフォーカルコニック状態での反射率は約4%であり、電極12a, 12b上に発生したブレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものではなかった。

【0077】なお、実験例8では、図10(B)に示すように、縦電界E 2'を発生させて液晶をブレーナ状態に変化させたとき、電極12a, 12bの厚みHが $3\text{ }\mu\text{m}$ と厚いため、前記実験例1~7と比較して、電極12a, 12b上と電極間隙上とで電界強度差(電界強度分布)が大きくなってしまう。その結果、液晶は電極12a, 12b上でブレーナ状態に変化しても、電極間隙上では若干フォーカルコニック状態のまま残ってしまう。また、同じ理由で電極12a, 12b上の液晶の厚みが薄くなり、ブレーナ状態が選択されても前記実験例1~7と比較してブレーナ状態での反射率は若干低くなり、全体の反射率(コントラスト)が若干低下する。

【0078】(比較実験例1、図11参照) 比較実験例1では、電極12a, 12bの電極幅Lを7μm、電極間隙Sを5μm、電極厚みHを0.2μm、セルギャップDを4μmとした。即ち、 $L/S = 1.40$ 、 $H/D = 0.05$ とした。まず、予め電極22と電極12a, 12bとの間に電圧を印加して液晶組成物Aをプレーナ状態とした。そして、電極12a, 12b間に周波数100Hzの±50Vのパルス電圧を100msで印加した。この場合、電極12a, 12b間に横電界E1が発生し、液晶組成物Aをフォーカルコニック状態に変化させる。同時に、電極12a, 12b上に縦電界E2'が発生し、この部分の液晶組成物Aをプレーナ状態にする。

【0079】このフォーカルコニック状態での反射率は約14%になり、電極12a, 12b上に発生したプレーナ状態は画像表示状態(特に、コントラスト)を損なう程のものであった。電極幅Lが7μmと広く、かつ、間隙Sが5μmと狭いと、電極12a, 12b上に縦電界E2'が多く発生し、フォーカルコニック状態を選択しているにも拘わらずプレーナ状態の液晶が多くなり、反射率が低下する。また、このような反射率の低下という現象は、電極12a, 12bの厚さHが0.2μmと薄いことも原因となっている。

【0080】(他の実施形態) なお、本発明に係る液晶表示装置は前記各実施形態に限定するものではなく、その要旨の範囲内で種々に変更することができる。

【0081】特に、表示装置としては、前記各実施形態で示した表示素子の1層で構成したもの、R, G, Bの各選択反射を行う表示素子を3層に積層したもの(フルカラー表示)、あるいは任意の波長の選択反射を行う表示素子を2層に積層したものなどで構成することができる。さらに、駆動回路の内部構成、その組合せは任意である。

【0082】また、前記実施形態では単純マトリクス型の液晶表示素子を例に挙げているが、画素ごとにスイッチング素子(例えば、TFT:Thin Film Transistor

や、TFD:Thin Film Diode)を有するアクティブマトリクス型の液晶表示素子においても本発明を適用できる。

【図面の簡単な説明】

【図1】液晶の動作原理を示す説明図。

【図2】IPS方式による液晶の動作原理を示す説明図。

【図3】実験例1の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図4】実験例2の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図5】実験例3の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図6】実験例4の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図7】実験例5の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図8】実験例6の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図9】実験例7の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図10】実験例8の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図11】比較実験例1の液晶表示素子を示す断面図で、(A)は横電界印加時、(B)は縦電界印加時を示す。

【図12】単純マトリクス駆動用の電極構成例を示す斜視図。

【符号の説明】

1…液晶表示素子

11, 21…基板

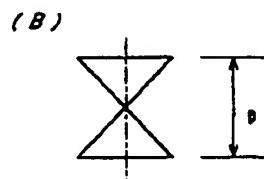
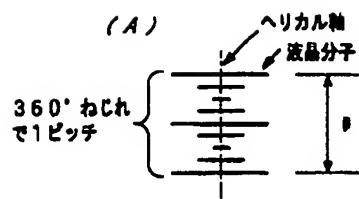
12a, 12b…櫛歯状電極

22…対向電極

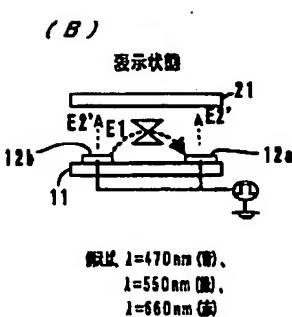
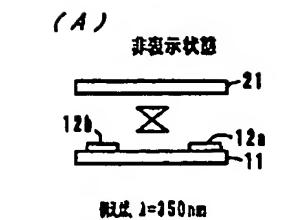
E1…横電界

E2…縦電界

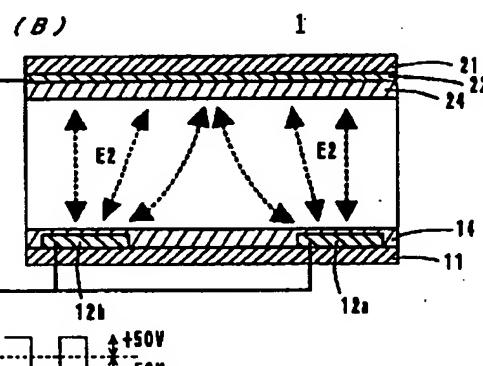
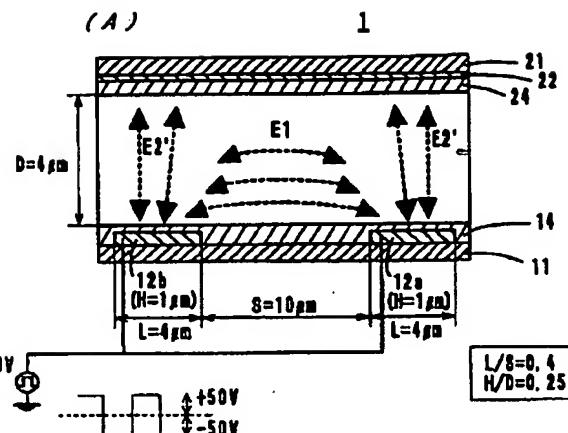
【図1】



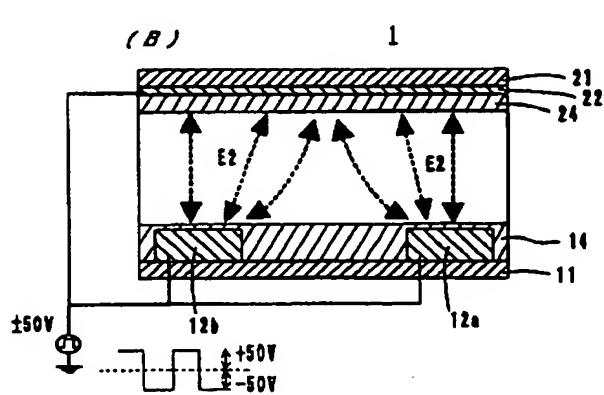
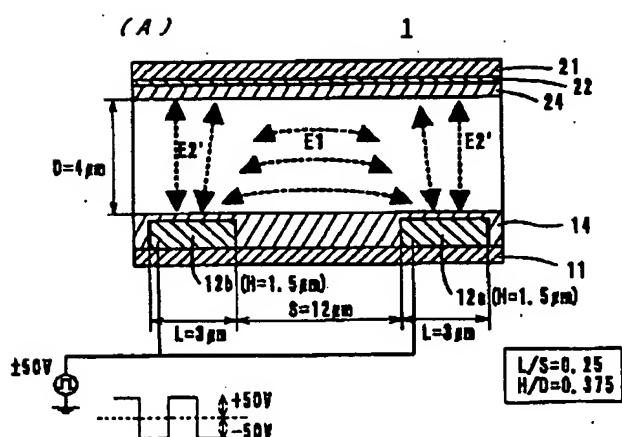
【図2】



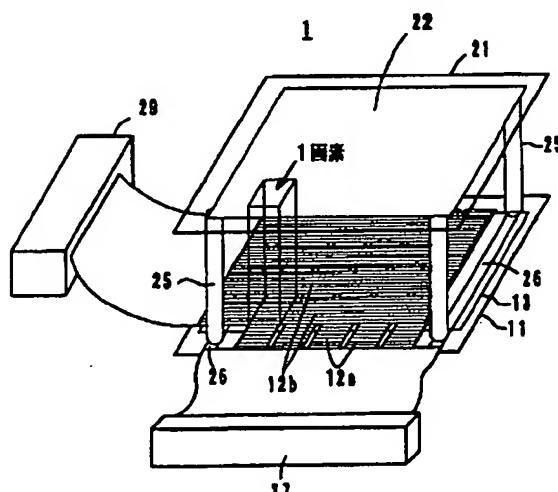
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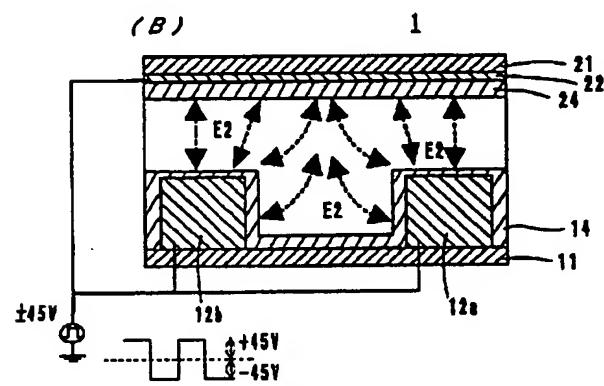
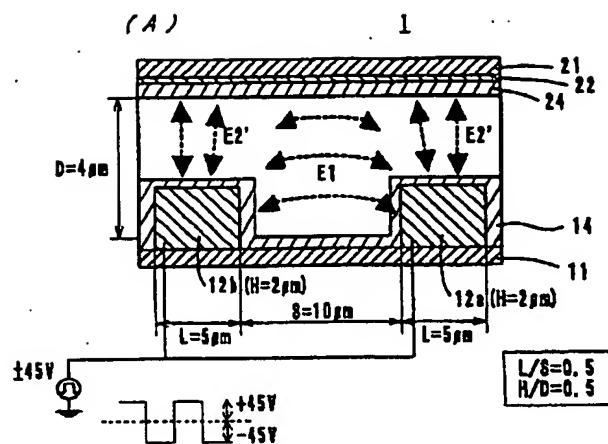
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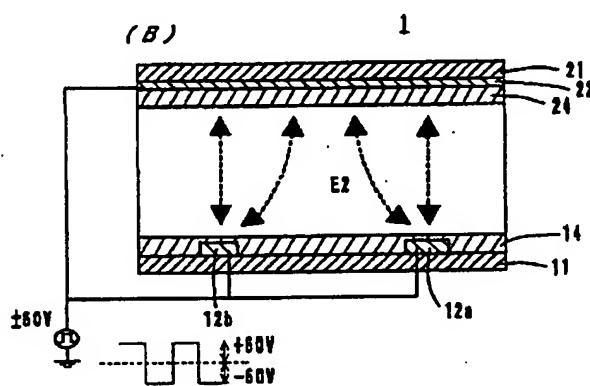
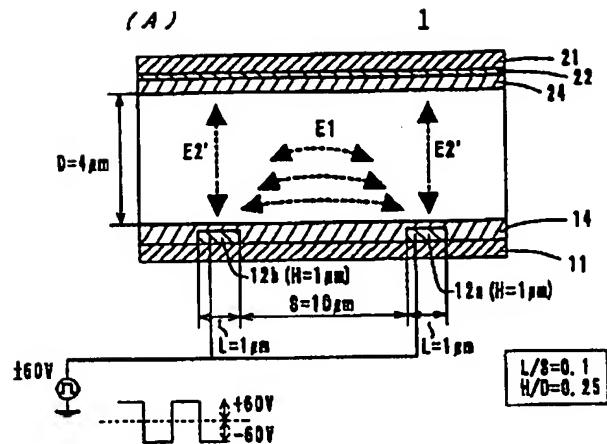
【図12】



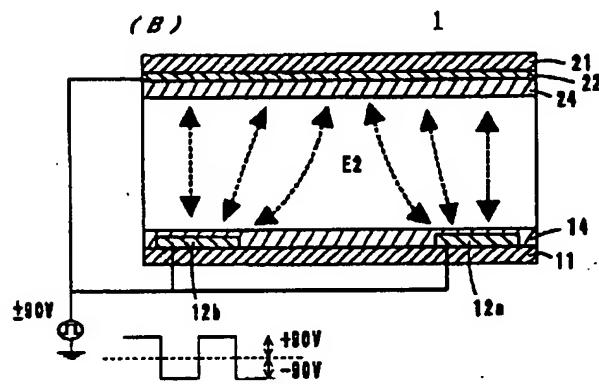
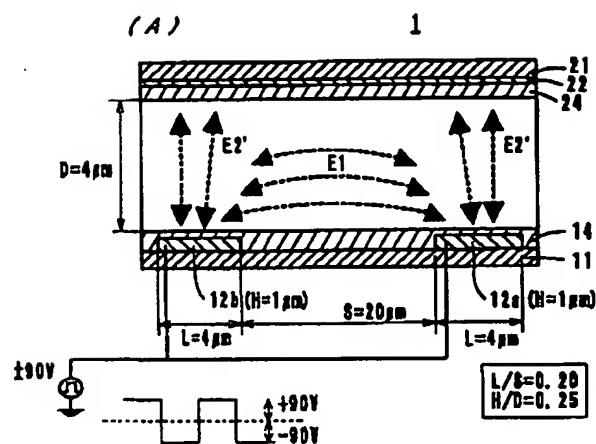
〔図5〕



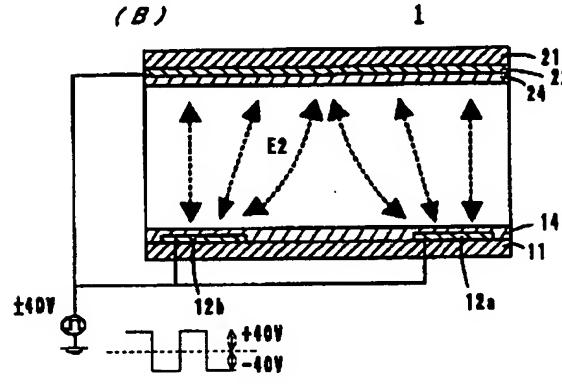
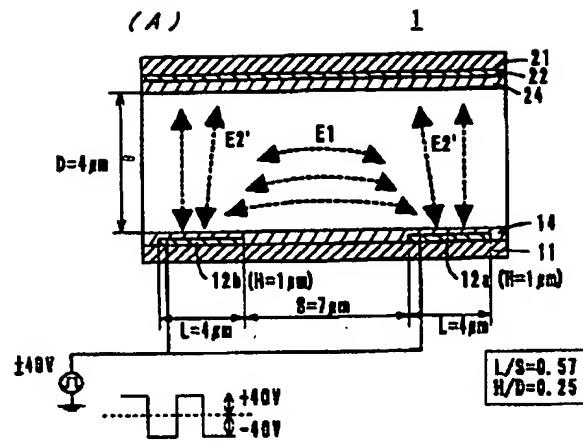
〔図6〕



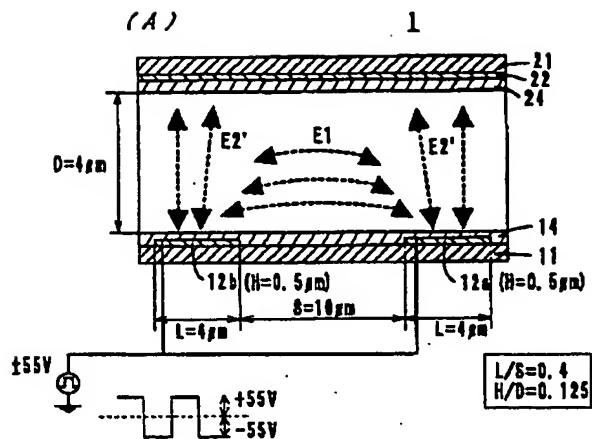
【図7】



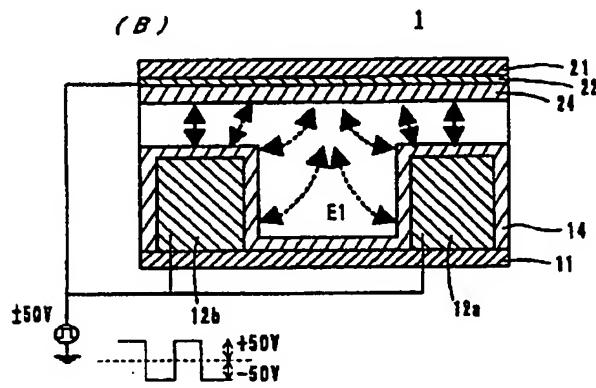
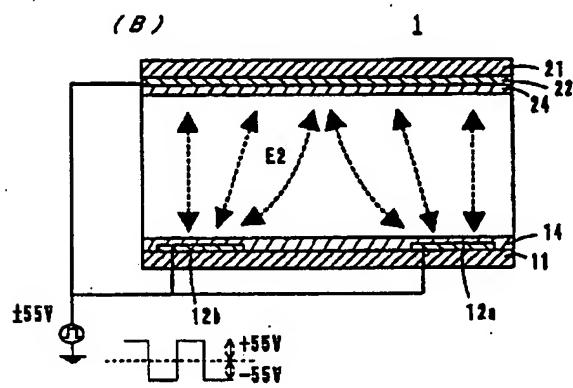
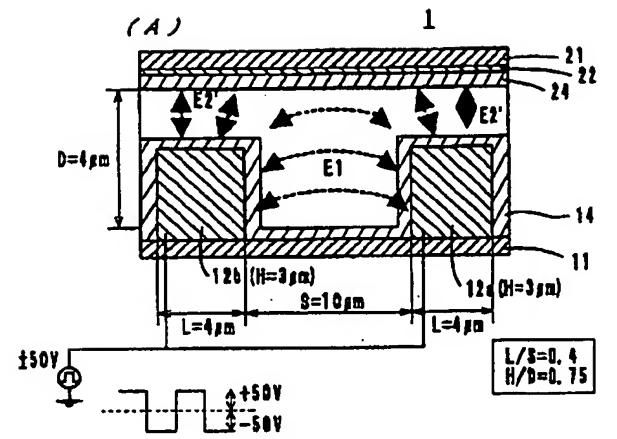
【図8】



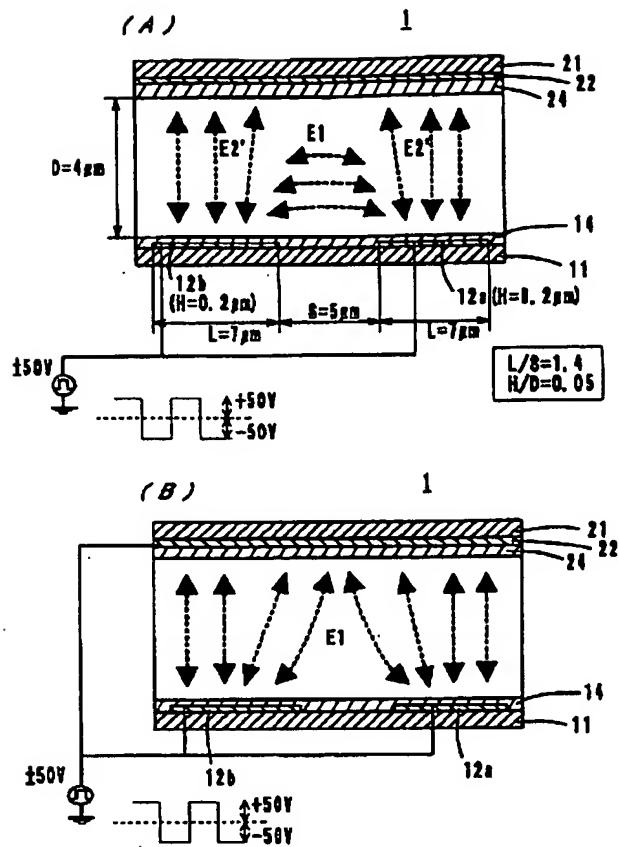
【図9】



【図10】



【図11】



フロントページの続き

F ターム(参考) 2H092 GA14 GA15 GA16 JB26 JB27
JB35 JB36 NA01 PA01